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THE BACTERIOLOGY OF PERITONITIS

By
Stanley
LEONARD S. DUDGEON
M.R.C.P. (Lond.)

Bacteriologist to St. Thomas's Hospital and Joint Lecturer on General Pathology in the Medical School; Director of the Louis Jenner Clinical Laboratory, and of the Pathological Laboratories, St. Thomas's Hospital; Erasmus Wilson Lecturer, Royal College of Surgeons of England

And

PERCY W. G. SARGENT
M.A., M.B., B.C. (Cantab), F.R.C.S. (Eng.)

Surgeon to Out Patients, Victoria Hospital for Children, Chelsea; late Resident Assistant Surgeon and Surgical Registrar, St. Thomas's Hospital; Erasmus Wilson Lecturer, Royal College of Surgeons of England

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TO

The Staff of St. Thomas's Hospital

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PREFACE

In this work, which formed the basis of the Erasmus Wilson Lectures of 1905, we have attempted to place the bacteriology of acute peritonitis upon a sound basis, and to deduce from the knowledge thus gained some facts which may serve to guide the surgeon in the treatment of the various diseases which are grouped under the general names of "septic" or "suppurative" peritonitis. When all such cases are treated on the same lines, it must sometimes happen that—

> The unthought-on accident is guilty,
> To what we wildly do.[1]

We think, however, that the time will come when it will be possible to treat these diseases with some regard to their bacteriology, and we hope that our results may be of some assistance in bringing about that desirable end.

In pursuit of our inquiry we have made systematic examinations of the peritoneum in two hundred and seventy cases operated upon at St. Thomas's Hospital during a period extending over about sixteen months.

We have, in the first place, to thank the Staff of St. Thomas's Hospital for the interest which they have taken in the work, and for the readiness and unfailing courtesy with which they have placed at our disposal the material obtained from their cases.

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[1] *Winter's Tale*, iv. 3.

We have been materially assisted by many former House Officers and Assistants in the Clinical Laboratory, whom we take this opportunity of thanking. Amongst them we would especially express our indebtedness to Drs. Bulley, Coutts, Harnett, Hedley, Inman, Pinches, Ross, Selous, Shipway, Spurrier, Upcott, and Wheen.

We have also to thank Dr. F. J. Child for much valuable help.

CHAPTER I

THE FUNCTIONS OF THE PERITONEUM

It is customary to regard the peritoneum as a vast lymphatic space of great absorptive power. Whatever may be the extent to which this power is exercised in the normal state, it is certain that, under abnormal conditions, the peritoneum is capable of absorbing large quantities of fluid. That which is left in the peritoneal cavity after copious flushing and closure of the abdomen, is transferred to the circulation with such rapidity as to be credited with a therapeutic action of the same nature as an intravenous infusion, a theory which receives support from the observation that, if such a case proves fatal, there is, at the autopsy, practically no fluid remaining, even when the patient has survived the operation only a few hours. It may be that this increased absorptive power after abdominal section may have some bearing upon the beneficent results obtained in cases of ascites and tuberculous peritonitis. Wegner found that a dog's peritoneum is capable of absorbing in one hour an amount of fluid equal to from three to eight per cent. of the animal's body weight. Dubar and Remy found the thoracic duct of a rabbit greatly distended in as short a time as five minutes after a large intraperitoneal injection of albuminous fluid. The greater the percentage of albumen, however, the less rapidly was the absorption effected.

This power of absorption is one of the factors to which the comparative safety of abdominal operations is largely due, for various fluids, even in large quantity, which at times soil the peritoneum during an operation, can be safely disposed of. The peritoneum in fact, to expand a trite expression, performs its own toilet.

This function, however, can only be exercised within certain limits, and it is to the factors lying beyond these limits that we must look for an explanation of many of the phenomena of peritonitis. It is important, in the first place, to understand in what manner, and by what channels this absorption is effected. The normal peritoneum is, save for the exception of the Fallopian tubes, a closed sac, closed microscopically as well as macroscopically. It is no longer held that the cavity communicates directly with the lymphatic system. Muscatello has shown the picturesque stomata of the older writers to have no greater significance than errors of histological technique. His researches showed that not only are there no stomata between the endothelial cells, but that there are not even any subendothelial lymphatic spaces over by far the greater part of the serous membrane of the abdominal cavity. The lymph spaces which underlie the endothelial covering of the diaphragmatic peritoneum are absent from that which is disposed over the viscera and abdominal wall His experiments with carmine upon the peritoneal cavities of dogs showed that the diaphragmatic is the only part of the peritoneum where fluid and solid particles are absorbed into the lymphatics, and that there is normally a lymph flow towards the diaphragm, independent of, but influenced in point of time by, gravity.

The structure of the diaphragmatic peritoneum is completely different from that of the rest of the serous membrane. It presents innumerable pits or wells, perpendicular or oblique to the surface, diving amongst the tendon bundles. They represent microscopic diverticula of the peritoneum, and like it, are lined in their whole extent by endothelial cells. Muscatello observed coloured particles taken up first into these intertendinous pits and then into the lymphatics. This transfer is carried out entirely by means of phagocytosis and is accomplished with extraordinary rapidity, for Dubar and Remy found particles of carmine in the thoracic duct only seven minutes after intraperitoneal injection. The irritation of the peritoneum with foreign substances is the signal for the entrance of numbers of phagocytic cells in a clear fluid exudate, the numbers being proportionate, partly to the time which has elapsed, but chiefly to the nature of the substance which has called them upon the scene. Sections of the diaphragm in cases of peritonitis show the lymphatic spaces crowded with leucocytes laden with bacteria.

Whatever absorption can not take place by the lymphatic channel must do so by means of the blood stream directly, and it is this which constitutes one of the greatest perils of peritonitis. Provided that the endothelium is uninjured, bacteria and other foreign substances will, within limits, be safely disposed of by the lymphatic route, but damage will at once permit absorption to take place by the vascular route. Indeed a parallel exists between the peritoneum and the skin. The uninjured hands may be soaked in virulent material with comparative impunity, but a slight abrasion may determine a rapid and even fatal absorption. The extreme delicacy of the peritoneal membrane (in its thickest part not more than 120 μ. in depth) renders it particularly susceptible to injury, and we have evidence to show that some at any rate of the fatal cases of peritonitis are due to a true septicaemia.

In cases of peritoneal infection, however, the patient's safety does not depend solely upon the integrity of the endothelium. The most rapidly fatal organism in peritonitis, in the human subject, is the streptococcus pyogenes. In cases dead of this infection there is observed an entire absence of agglutination of the intestinal coils, a phenomenon which is early observed in the case of an infection to which the peritoneum reacts, and this fact goes hand in hand with the differing behaviour of the phagocytes in the two cases. This agglutination is due to a fibrinous deposit upon the peritoneum, and we may say that, as a rule, the longer the infection has lasted, the greater is the amount of fibrin deposited upon the peritoneum. We refer, not so much to the visible flakes of fibrin, which may be produced in the fluid exudate and in this form deposited upon the peritoneum, as to the more or less uniform microscopical deposit.

Sections of intestine from a case of gastric perforation, (Fig. 1), operated upon sixteen hours after the onset, which proved fatal from shock almost immediately after the operation, but with very little naked eye evidence of peritonitis, show the endothelial layer intact and covered with a microscopic deposit of fibrin, in the meshes of which are entangled innumerable leucocytes. There is also seen a round celled infiltration of the subendothelial tissues, which, however, becomes less as the intestinal lumen is approached, whilst the mucous membrane is unaffected. At this stage, then, the endothelial layer is, as it were, sandwiched between the fibrinous deposit and the underlying area of round-celled infiltration. Turning now to the diaphragm in a case of peritonitis due to appendicitis, of five days' duration (Fig. 2), which proved fatal almost immediately after a limited operation, this deposit is seen to be very much more marked, the subendothelial infiltration more intense, and the endothelial layer itself indistinguishable. A more advanced instance still is that of a case

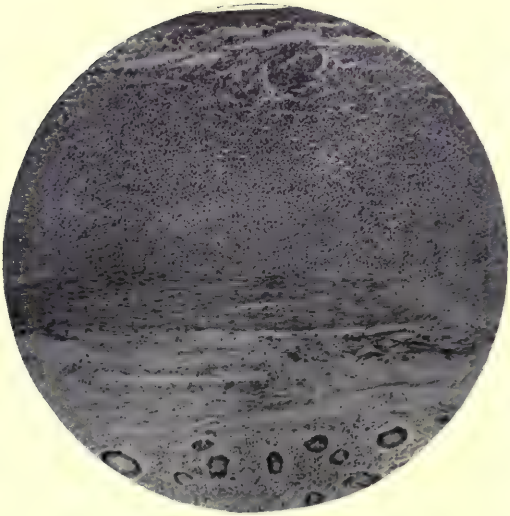

FIG. 1.—Section of intestine in a case of peritonitis, due to gastric perforation, which proved fatal sixteen hours after the onset. Specimen shows the enormous inflammatory deposit, which gradually becomes less as the mucus coat is approached. There was very slight evidence of peritonitis at the time of the operation.

[*No.* " *B* " *eyepiece ;* $\frac{2}{3}$ *obj.*]

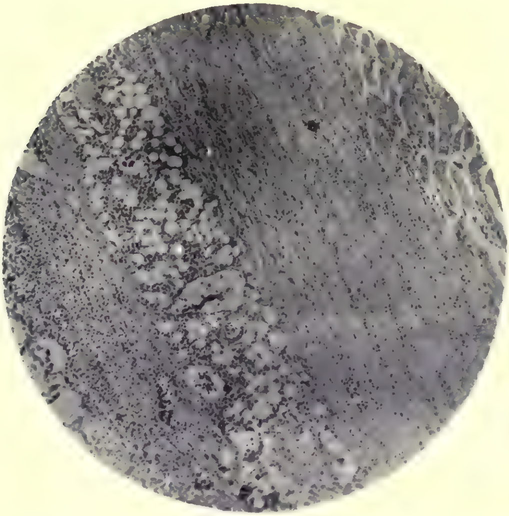

FIG. 2.—Section of diaphragm in a case of peritonitis, due to appendicitis of five days' duration, which proved fatal almost immediately after operation. Inflammatory exudation extremely well shown, extending down into and fading off in the muscular coat. Endothelial layer is no longer visible.

[*No.* " *B* " *eyepiece ; 2 inch obj.*]

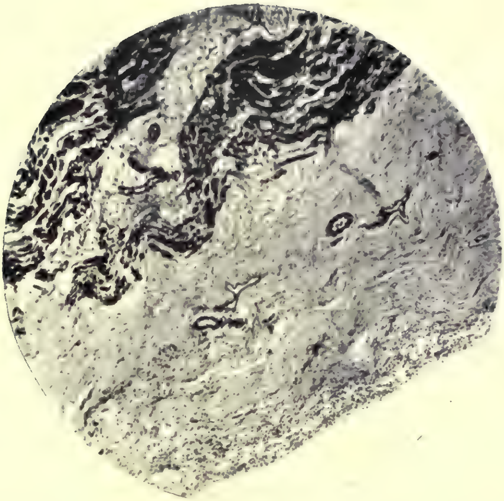

Fig. 3.—Section of diaphragm, showing organization of fibrous tissue in a case of chronic septic peritonitis.
[*No. "B" eyepiece ; ⅔ obj.*]

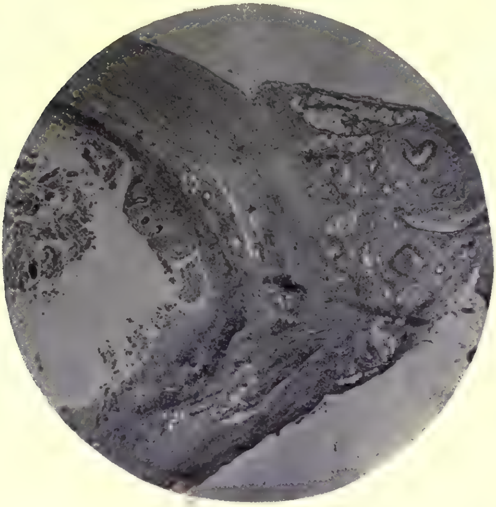

Fig. 4.—Section of vermiform appendix, showing thrombosis of mesenteric vessels. Mucus membrane almost entirely destroyed. With a high magnification, enormous masses of bacilli can be seen in the wall of the appendix.
[*No. "B" eyepiece ; 2 inch obj.*]

of chronic suppurative peritonitis which proved fatal seven weeks after the opening of an appendix abscess (Fig.3). Here there is enormous thickening of the peritoneum, degeneration of the underlying muscle, and disappearance of the endothelial layer. The deeper layers of the deposit are organized into fibrous tissue, and, as the coelomic surface is approached, this tissue is less and less perfectly organized, until, at the surface itself, we come to the amorphous fibrinous deposit which is seen in the other cases.

We conclude that this fibrinous deposit serves a protective function, both limiting the absorption of toxic material into the subperitoneal blood vessels, and at the same time preventing the further egress of organisms from the intestine into the peritoneal cavity. The absence of this deposit from the most acute cases of all allows a fatal issue to occur from haemic absorption. Another way in which this fibrinous deposit serves as a protective measure is by the agglutination of intestinal coils, whereby a localization of infection may be brought about.

If the peritoneal infection subsides before the endothelium is irrevocably destroyed, then the fibrin is absorbed, and the peritoneum resumes its normal appearance, although in consequence of the subendothelial infiltration, it remains permanently thickened. This explains the almost miraculous disappearance of adhesions which is the wonder of the surgeon when he comes to reopen the abdomen some months after the occurrence of an intra-peritoneal abscess. The permanent thickening explains, in part at any rate, the resistance to infection which is conferred upon the peritoneum after a previous inflammation. If, however, the endothelium has been destroyed, and the fibrinous deposit has had time to organize, then persistent adhesions must result.

It will be seen that the pulling off of fibrinous plaques at an operation is to be deprecated, as it lays bare the subperitoneal vessels for absorption, and that any rough handling which damages the endothelium is likely to be rewarded by the formation of persistent adhesions. It will also be seen that the thorough cleansing of the peritoneum by washing is not only, as is shown in another place, undesirable, but a physical impossibility.

What happens when micro-organisms are introduced into the peritoneal cavity depends upon the virulence of those organisms and their power of so damaging the endothelial covering as to gain access to the subendothelial tissues; upon the power of the individual to produce a leucocytosis, upon the stimulating action of the body fluids, and upon the ability of the phagocytes to deal with the organisms. We believe the virulence of the organisms, and the rapidity with which they are introduced to be of greater importance than the actual dosage. It is notorious that in many pelvic operations large quantities of purulent fluid may escape into the peritoneal cavity with impunity; the explanation lies in the extremely low degree of virulence of the organisms commonly met with in gynaecological work. Again, peritoneum, soiled as it must be with intestinal contents during anastomotic operation under healthy conditions, rarely becomes the seat of a spreading inflammation of any consequence, but similar operations undertaken during intestinal obstruction, when the virulence of the intestinal organisms is exalted, are attended with a much greater risk. The objects of our enquiry, then, are to ascertain the nature and varying virulence of the organisms met with in peritonitis; their relative frequency; the natural protective agencies which are at the disposal of the patient; and the means whereby those agencies may be aided by surgery.

THE FUNCTIONS OF THE PERITONEUM

We have thought it advisable to eliminate the term "general" as applied to peritonitis, since it is used loosely in two very different senses. By some the term is used to signify that the inflammatory process involves the whole peritoneal surface, and by others that it is unlimited by obvious adhesions and is in the process of spreading after the fashion of a cutaneous erysipelas. For the former meaning we have adopted the name *universal*; and for the latter *diffuse*, a term which implies no expression of opinion as to the extent of the infection, but merely that it is unlimited by definite adhesions. By adhesions we mean every stage from the mere agglutination of neighbouring peritoneal areas to definitely organized tissue.

From the appearances seen at operation it is impossible to form an opinion of any value as to the extent of the peritonitis present. It is customary to gauge it by the degree of redness and distension, and by the naked eye appearance of the exudate, but we are convinced that none of these criteria are reliable. G. W. Crile has shown that the stimulus supplied by opening the abdomen and manipulating the intestines is sufficient to produce a rapid dilatation of the vessels of the splanchnic area. If one watches a given coil of intestine during an abdominal operation, one is struck with the rapidity with which its appearance alters. A coil which, on opening the abdomen, appears flabby and slate coloured or quite pale, on exposure and manipulation takes on first a general flush, and soon afterwards one can see the sub-peritoneal vessels mapped out. At the same time the lumen appears to fill with gas and to become distended. If the operation is prolonged, or the manipulation is at all violent, the changes are such that an observer, seeing it for the first time, would pronounce some degree of peritonitis to be present. These changes occur much more rapidly in conditions of obstruction or peritonitis, so that at the end of the operation the peritonitis appears to be more severe in degree and extent than at the beginning. To estimate the peritonitis present, then, even by the usual criteria, the observation must be made immediately the abdomen is opened.

Now if, as Crile holds, shock is due to reflex vaso-dilatation of the splanchnic area, then such a condition as the crushing of a limb will be accompanied, unseen, by an increased vascularity of the intestines. Shock from the sudden strangulation of a hernia or the perforation of a gastric ulcer will be accompanied by similar changes, so that, on opening the abdomen, a more extensive degree of peritonitis will appear to be present than is actually the case when tested by bacteriological means.

In reviewing the somewhat scanty literature of peritoneal bacteriology, we have been struck with the fact that the bulk of it has been done from material obtained from the post-mortem room. When we recognize the rapidity with which the colon bacillus invades the tissues after death, and even, according to some observers, before death, we see how little reliance can be placed upon such observations. Bumm, Tavel and Lanz, and others, agree that bacteriological observations upon the peritoneal exudate are useless three hours after death. A good example is a case recorded by Charrin and Veillon, of pneumococcic peritonitis occurring as a terminal event in cirrhosis of the liver. An hour after death the pneumococcus was found in pure culture in the peritoneal exudate, but at the autopsy, twenty-six hours later, only the colon bacillus could be identified from the same exudate.

It is to the early stages of peritonitis that we must look for an explanation of its bacteriology. To concentrate the attention upon an extreme stage such as an abscess swarming with a multitude of different organisms from a perforated or gangrenous appendix, is as likely to be attended with success as would an investigation into the bacteriology of a case of gangrene based upon the examination of a putrefying slough.

Strangulation of a knuckle of gut, leading first to vascular changes and alteration in permeability of the gut wall, and later to peritonitis from necrosis or perforation, is, on a large scale, what appendicitis is on a small one. Obstruction of the appendix, from stricture, concretion or kinking, gives rise to the same series of changes, but often with much greater rapidity, since it occurs in a region in which as Corner has pointed out, bacterial activity in the intestinal canal is at its maximum.

It is about the colon bacillus in its relation to peritonitis, and incidentally to appendicitis, that the most widely diverse views are held. Whilst Tavel and Lanz considered it to be of no greater importance than other intestinal organisms, Laruelle considered it to be the pathogenic agent in perforative peritonitis, and Malvoz went further, regarding it as the pathogenic agent, not only in perforative peritonitis, but in all other forms of peritonitis of intestinal origin. On the other hand, there is the view which has more recently gained ground, that "the colon bacillus, being more in evidence, is frequently held responsible for peritoneal infection due to a more virulent but culturally less vigorous organism." This theory has been pressed still further by other writers, some of whom inculpate the pyogenic cocci, whilst some lay the blame upon certain obligatory anaerobic bacteria, both using these elusive organisms as scapegoats in order to exonerate the colon bacillus. The result of our observations supports neither of these two last named views, and we consider that the colon bacillus plays by far the largest part in hurrying our peritonitis cases from the wards to the post-mortem room. Other organisms are equally or even more fatal when introduced into the peritoneal cavity, particularly the streptococcus pyogenes and the bacillus pyocyaneus, but they are of comparatively rare occurrence.

The virulence of the colon bacillus varies in different situations and with different pathological conditions. In the dog, according to Klecki, it is, under normal conditions, least virulent in the jejunum and most so in the ileum, whilst in the colon it occupies an intermediate position. Taking samples in artificial strangulation, from the same animal he found the bacillus to be least virulent in the normal bowel, and most so in the strangulated bowel. The organism when obtained from the peritoneal exudate proved to be of a lower degree of virulence than that from the strangulated loop whence it had made its way. Lessage and Macaigne found that diarrhœa rendered the colon bacillus more virulent. Welch found the bacillus in one or more organs post mortem in 33 out of 200 cases; in all these 33 cases there was some intestinal lesion present.

In these observations lies the explanation of certain facts which are well known clinically. During a state of intestinal repose anastomosis is performed with a degree of safety which is practically dependent only upon the technique of the operator, but during acute intestinal obstruction the chances of peritonitis from the same operation are very largely increased.

But the comparative virulence of the infecting organisms is not the only factor. There are variations in resistance on the part of the peritoneum. Many experimenters have shown that the resistance of the peritoneum can be artificially increased. Issaeff in 1894 was the first to show that various sterile solutions previously injected into the peritoneal cavity of guinea-pigs could render that membrane more or less refractory to infection with certain pathogenic organisms. In the following year Melsome and Cobbett, working with cultures of "streptococci," showed that an immunity could be produced by successive minute inoculations. Durham obtained similar results in rabbits from preliminary injection of sterile fluids. More recently Salieri, and Miyake working under Prof. von Mikulicz, have confirmed these observations, and succeeded in producing an artificial immunity in animals by preliminary intra-peritoneal injections of sterile saline solution, nucleic acid, and other substances. The protection thus afforded is, as Durham pointed out, due in large measure at any rate to the appearance in the peritoneal exudate of certain phagocytic cells. It is a general, not a specific, immunity against peritoneal infection.

The question arises whether this artificial protection has any counterpart in the natural events of peritonitis. We believe our observations to show that it has.

We have been struck with the extreme ease with which organisms make their way into the peritoneal cavity in many abnormal conditions, even in the early stages of intestinal obstruction.

The organism which, as we have shown in a very large number of cases, is usually the first to make its appearance in the peritoneal cavity is the *staphylococcus albus*. We have found it in almost every variety of peritoneal lesion which has come under our notice. As a general rule it is to be found on the peritoneal surface at a distance from the focus of most severe disturbance, and in association with numbers of phagocytes.

It is an organism of very low virulence. Present in many cases of intestinal obstruction and of strangulated hernia, it does not produce, when once the obstruction has been relieved, fatal peritonitis, and rarely suppuration of the parietal wound ; present beyond the area of acute infection in cases of appendicitis, it produces no spreading peritonitis when the abscess has been opened or the appendix removed ; present invariably in the bloody exudate of ruptured tubal pregnancy, it produces in most cases nothing more than a febrile disturbance of little moment. In guinea-pigs it can be inoculated intra-peritoneally without fatal effect. The effect which, as we have seen, it does produce, is to determine the advent of numbers of phagocytic cells. Again, in cases of spreading peritonitis the outlook is better when this organism is found beyond the area of most intense infection, in a remote region of the peritoneal cavity.

All these facts lead us to the conclusion that the staphylococcus albus exercises a protective action in peritonitis, and that by determining the advent of phagocytes. It therefore, in nature, takes the place of those chemical substances which have been found by Miyake and others to be capable of producing an artificial immunity. How or why this staphylococcus appears upon the scene we do not know and we are unable even to hazard a guess.

Having arrived, however, it seems to provoke the appearance of a clear fluid exudate, which soon becomes turbid from the presence of innumerable phagocytic cells, and the more turbid it becomes, the more it appears to the surgeon as something to be washed away. Later the more virulent organism, in the majority of cases the colon bacillus, appears, and it is upon the start, so to speak, which the white staphylococcus has had, and the ability of the individual to respond to the call, that the prognosis to a large extent depends, provided that the natural safeguard is not interfered with by violent treatment. Generally speaking, we conclude that if in a case of peritonitis the staphylococcus albus is found alone in a remote region of the peritoneum, the outlook is much better than if it is found in association with the colon bacillus.

Animal experiments show that by the simultaneous inoculation of the staphylococcus albus and the colon bacillus little or no protective action is exerted, but that, if the staphylococcus is given a start of some hours, an artificial immunity is secured. In these experiments the organisms used were obtained from cases of peritonitis, and control experiments were simultaneously carried out.

As the staphylococcus albus is usually the first to appear, so it is the last to disappear when the individual has overcome the infection, for it has been found to persist in some cases in the peritoneal cavity long after the other organisms have vanished. This may serve to explain the comparative rarity with which acute infective appendicitis occurs if there have been previous attacks. By far the largest number of the so-called fulminating cases of appendicitis are first attacks.

There is a second way in which the staphylococcus albus may be regarded as having a protective action, and that is by assisting the formation of adhesions. In many cases cultures taken from the midst of recent peritoneal adhesions, in the stage when they exist only as coagulated fibrinous exudate, show this organism to be present. A good instance of this, in our series, was a case of hepatic abscess with adhesion formation. The abscess was situated close to the surface of the right lobe, and the liver was in process of being glued to the anterior abdominal wall by flimsy adhesions. Coverslip preparations of this material showed polynuclear and mononuclear cells only, whilst the cultures gave a pure growth of the staphylococcus albus. The leucocytes probably produce the early stage of adhesions by determining the coagulation of the exudate. The agglutination of the intestines in its turn places a mechanical restraint upon the spread of peritoneal infection.

From what we have stated the question naturally arises whether it is possible to form an opinion as to the probable course of a case of peritonitis from an examination of the exudate. Culture methods, from the time consumed, would be of little value—although the colon bacillus can often be identified in as short a time as four hours in broth cultures incubated at 37° C.—but we believe that it is possible to make a prognosis from the microscopical examination of films taken from a remote region of the peritoneum. If phagocytes are abundant, and if staphylococci, are present, the prognosis should be favourable. If bacilli also are present, but if cells are abundant and cocci appear to predominate, the outlook is more grave but not necessarily hopeless. But if cells are scanty and disintegrated, and bacilli are alone or present in very large numbers, or if streptococci are present, then the case may be regarded as hopeless.

As a result of our observations we have been led to formulate a theory which appears to us to explain many of the phenomena of peritonitis. In every class of case we have found the staphylococcus albus to be the first organism to appear in the peritoneal cavity, and it is only reasonable to assume that it makes its way out, if indeed it does come from the intestine, at the point of most severe damage. But where the damaged intestine is of large extent, as in a volvulus for example, we find that organism distributed indiscriminately over a very large area of gut surface. It seems probable, therefore, that as soon as the intestine becomes distended and congested, the organism makes its way out at any and every point, to be followed at a later period, if the obstruction is unrelieved, by other organisms, notably the colon bacillus. Similarly in peritonitis of intestinal origin due to causes other than obstruction, we believe that organisms make their way out, not only at the primary focus, but also from each successive portion of intestine as it becomes inflamed and distended.

If this is so, then several of the phenomena of peritonitis are accounted for which are otherwise difficult to explain. First, it accounts for the rapidity with which a vast area of peritoneal surface becomes involved, and that in spite of any intestinal paralysis which may be present. Secondly, that the stimulus for the advent of enormous masses of phagocytes is rapidly applied over a large area. Thirdly, that the staphylococcus albus is so frequently found in advance of the other organisms present. Fourthly, that we so frequently find organisms on the surface of the gut, but not always, in the same cases, in the exudate. They are practically never found in the exudate when they are not present on the gut surface. This is an observation which has been made by other observers, notably Durham, who attributed it to the deposition of organisms from the exudate upon the peritoneum, in much the same manner that organisms tend to settle to the bottom of a culture tube in which they are growing. Lastly, this view explains how it is that in a subsiding peritonitis residual abscesses may be formed in any situation, and without any direct connection with the original focus of infection.

CHAPTER II

TECHNIQUE

In the large majority of cases the films and cultures were taken by one of us ; almost all the remainder were taken under the immediate supervision of one of us whilst operating. This goes far to ensuring uniformity of method and observation in our series.

One of our objects being to inquire into the bacteriological condition of the peritoneum at a distance from the primary lesion, the first culture tube was inoculated with the platinum-loop which was introduced into the abdominal cavity directly the peritoneum was opened. In the majority of cases there was at least sufficient fluid, whatever the nature of the disease, to furnish a loopful easily. When possible, a cover-slip preparation was made of this fluid also.

The second culture tube was inoculated either from the peritoneal exudate, or by drawing the loop over the surface of the gut in the immediate neighbourhood of the lesion. The films were prepared from the same region, either with the exudate here, or, in the absence of exudate, by drawing a sterile coverslip directly over the surface of the intestine.

We may here point out that we believe the uniformity of our results to have been largely assisted by the operative methods employed by the surgeons of St. Thomas's Hospital. No chemicals are used for the instruments or any part of the operation, and consequently we avoided the errors which might have arisen had minute amounts of antiseptic solutions been introduced along with the exudates into our culture tubes. Our attention was drawn to this point in connexion with some cultures taken in the gynaecological theatre, where such solutions are employed to some extent; and where the growth of the organisms was undoubtedly retarded in that manner. When Dr. W. W. H. Tate, at our suggestion, very kindly discarded the chemical solutions until our cultures had been taken, our results at once fell into harmony with those obtained in the other operating theatres.

As a control experiment we took cultures in precisely the same manner from twelve consecutive cases of abdominal operations undertaken for exploratory purposes, in which neither obstruction nor inflammatory disease was present. The culture media invariably remained sterile.

In the majority of the cases rubber gloves were used by both operators and assistants. Even then, every precaution was taken, in making the cultures, to avoid any region which had been touched with the fingers.

Bacteriological technique.

In all investigations such as this it is most desirable that a full account of the various methods employed should be accurately given, in order that others should have an opportunity of forming their own opinion with regard to the organisms found. In reviewing the literature of peritoneal bacteriology, we have frequently found bare statements, without any reference to the technique, such as "typhoid bacilli were present," "the pneumococcus was found in the exudate," and so on. Such statements may be perfectly correct, but one would prefer to have at least an outline of the evidence upon which they rest. Again, the names "staphylococci" and "streptococci" are often used in a manner which leaves the reader in doubt as to what organisms are meant.

Cover-slip preparations.

It is always necessary to examine film preparations of the fluid, pus, or other material from which the original cultures are made. This was done in the large majority of our cases, and the films were stained by Gram's method, and sometimes with Prof. Leishman's stain.

The following is the techinque which was adopted for Gram's method :

1. Place the film in carbol gentian violet[1] for five minutes.
2. Gram's iodine for thirty seconds.
3. Wash in methylated spirit until the film has a faint blue colour.
4. Stain in weak carbol fuchsin for two minutes.
   (A few drops of carbol fuchsin in 10 c.c. of water.)
5. Wash in acetic acid water.
   (A few drops of acetic acid added to the water to impart a faint odour.)
6. Dry-mount.

If thick films of pus have been taken, there is usually some difficulty in decolorizing in methylated spirit, and one is apt to remove the colour even from cocci which otherwise would stain by Gram owing to the difficulty in removing the stain from the leucocytes. If films of pus, however, are taken in the same manner as blood films, this difficulty is immediately overcome.

Cover-slip preparations were also made of the various cultures which were taken in each case, and these were also stained by Gram's method. By this means we were able to form some idea of the nature of the aerobic and anaerobic organisms which were present in the original broth cultures.

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[1] Saturated alcoholic solution of gentian violet, 1 c.c.; Acid. Pheno (dil. 1 in 20), 9 c.c.

Anaerobic culture methods.

Cultures were taken in glucose broth, or sodium formate glucose broth (Kitasato), or sodium sulphindigotate glucose broth (Weil). The last mentioned medium is a deep blue colour, and is decolorized to a light or dark yellow during the growth of anaerobic organisms. Glucose agar and glucose jelly were used for anaerobic plating. Anaerobic tubes if incubated singly were placed in modified Buchner's tubes; if many tubes or plates were inoculated, Bulloch's anaerobic apparatus was used. The simple and ingenious tubes suggested by Wright of Boston were used on numerous occasions. The great advantage of these tubes is the easy and accurate method by which we can compare the aerobic and anaerobic growth of an organism. Glucose agar and glucose jelly roll cultures were also grown anaerobically according to Wright's method. We do not consider that roll cultures are of any particular value.

Aerobic Cultures.

The original cultures were generally taken in broth, but on certain occasions blood agar, blood serum, litmus milk and glycerine broth were employed. Every important medium has been used at various times for the growth of the various micro-organisms isolated in these cases. No advantage, however, would be gained by enumerating all the anaerobic and aerobic media which have been employed.

Isolation and Separation of Micro-organisms.

In almost every case the original cultures were plated on various artificial media, of which the most useful were found to be gelatine, neutral red jelly, agar, and the medium of Drigalski and Conradi. There can be no question that the most useful media are gelatine and the medium of Conradi and Drigalski. The plates which were found to be most satisfactory measured four inches in diameter.

It is of course absolutely necessary to use this method for the separation of micro-organisms.

Inoculated Media.

We cannot insist too strongly on the importance of watching the effect of inoculation of artificial media for a considerable length of time. It is quite useless to give an opinion as to whether a micro-organism does or does not liquefy gelatine, for example, unless the jelly tube has been in the incubator for one month from the date of inoculation.

Serum Tests.

The agglutination reactions were always observed microscopically. A young culture was used for the reactions without exception. In every case this was either a glycerine agar or an ordinary agar culture. Broth cultures were never employed, owing to the tendency of cocci and bacilli to agglutinate when growing in these media. The emulsion of the organism was made with physiological salt solution, and also with the 0·1 per cent. solution recommended by Dr. A. E. Wright.

Dilutions of 1 : 10, 1 : 20, 1 : 50, and 1 : 100 were employed, but the two last mentioned dilutions were not used systematically. The blood was diluted with physiological salt solution. In those cases in which a positive agglutination was obtained, a control test was made with normal blood. It is hardly necessary to add that a control culture was examined under the microscope during the whole period in which the agglutination test was being employed.

On some occasions the emulsions of staphylococci showed a tendency to spontaneous agglutination ; in such cases the emulsions were filtered through a double thickness of filter paper, and if this was found to be of no avail, emulsions were made from fresh cultures at a later date.

Animal Inoculation.

The animals which were used in these experiments were rabbits, brown and white mice, and guinea-pigs. The inoculations were made intra-venously, intra-peritoneally, and subcutaneously, with sterile glass syringes. A young broth culture was used in every case. Every post-mortem examination was made as soon as possible after the animal's death. A hanging drop, a film preparation, and cultures were invariably made from the affected tissues.

Microscopical Examination of the affected Tissues.

Microscopical preparations were made of the affected tissues in some cases. The sections were cut in paraffin and stained by Gram's method, Leishman's, and with haemalum and eosin. The appendix vermiformis and the walls of gastric ulcers were used from human sources, and the diaphragm and various mediastinal glands of guinea-pigs which had died from severe peritoneal infections subsequent to inoculation.

We have given here a brief sketch of some of the methods adopted during this bacteriological investigation. A detailed description of any special technique will be found under the various sections.

CHAPTER III

INTRAPERITONEAL HAEMORRHAGE

There are at the present time those who, whilst admitting the bacterial origin of most diseases, are yet willing to accept the theory that peritonitis may, in certain conditions, be due to causes other than, and independent of, microbic infection. It is held that sterile fluids are capable, when introduced in sufficient quantities into the peritoneal cavity, of setting up a non-bacterial form of peritonitis, and to this variety the term " chemical peritonitis " is applied. One result of our investigations upon the peritoneal exudate in cases of haemorrhage has been, not only to cast very considerable doubt upon the existence of chemical peritonitis, but to guide us in the interpretation of other forms of peritonitis also.

So far as we are aware, the bacteriology of intraperitoneal haemorrhage has not hitherto been seriously investigated. The only mention of such a case which we have been able to find is by Malvoz, who, in 1891, in a case of ruptured tubal pregnancy, withdrew some fluid with a sterile aspirator before the abdomen was opened. The blood yielded a pure culture of the colon bacillus, but as there is nothing to show that the bowel was not traversed, we cannot attach much importance to this observation.

We have investigated twenty cases of intraperitoneal haemorrhage, seventeen being due to extra-uterine pregnancy, two to rupture of the spleen, and one to rupture of the liver. In the cases of ruptured tubal pregnancy, culture tubes were inoculated with the fluid which appeared directly the peritoneum was opened, and others from the blood clot, whether old or recent, in the pelvis. Cover-slip preparations were made from the darker blood in the pelvis, and these were stained by Gram's method. In three cases gram-positive cocci were found in the films taken in this manner. By cultures, the staphylococcus albus was isolated four times from the peritoneal cavity. *From the blood clot, however, a white staphylococcus was obtained from every case without exception.* In all the traumatic cases cultures from the blood were sterile, and in two the staphylococcus albus was obtained in pure culture from the blood clot. Only one case of the whole twenty instances of intraperitoneal haemorrhage was completely sterile, and that was operated upon within two hours of the accident.

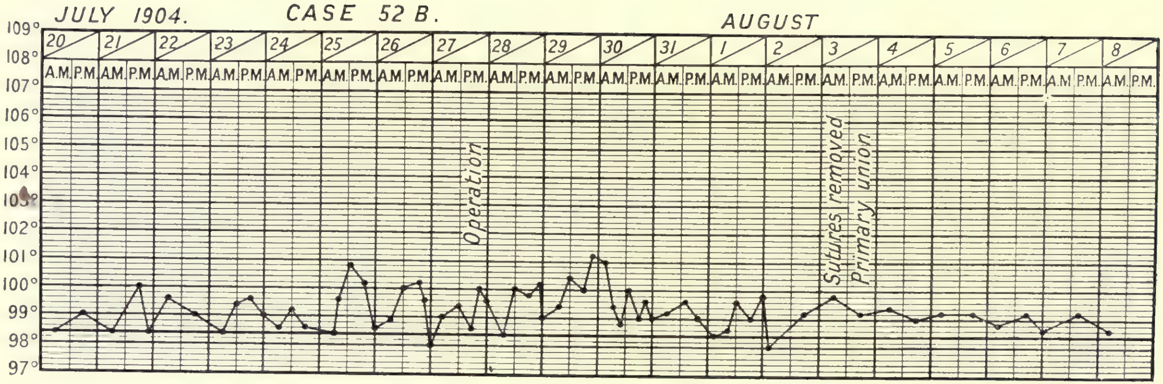
It is well known to gynaecologists of experience, and it is owing to the kindness of Dr. Cullingworth that we have become acquainted with the fact, that a pelvic haematocele, if left alone, may after a time become infected, so as to give off, when opened, a musty or other unpleasant smell. Moreover, in days gone by, pelvic haematocele was not an infrequent cause of pelvic abscess. This liability to infection, Dr. Cullingworth points out, is a strong argument in favour of operating upon all cases of pelvic haematocele. That a long standing case is liable to infection, then, is well known, but that every case, even a few hours after the extravasation, becomes infected with micro-organisms, has not hitherto, so far as we are aware, been ascertained. Again, cases of traumatic haemorrhage which do not prove immediately fatal may, if the blood is in large amount, give rise to diffuse peritonitis, and the following three cases reported by Herbert Page are good examples of such a sequel. He, however, did not attribute the peritonitis in his cases to bacterial infection. The first was a case of rupture of the spleen in a boy aged fourteen. The abdomen was opened twenty-four hours after the accident, when a large quantity of dark blood was found in the peritoneal cavity, but there was no evidence of peritonitis. The intestines were distended and "roughened." Death took place four days later, and at the autopsy recent lymph was present in the abdomen. The second was a case of ruptured liver in a boy ten years of age. Twelve hours after the accident there were signs of peritonitis present, and twelve hours later again, as the peritonitis was more marked, the abdomen was opened. The liver was found to be ruptured, and there was a quantity of dark blood in the peritoneal cavity. The intestines were reddened and distended. At the autopsy the intestines were found to be inflamed and adherent. The third case was one of ruptured liver in a man of twenty-two. The abdomen was opened twenty-four hours after the accident, when a large quantity of dark blood was found in the peritoneal cavity. Death took place shortly after the operation. At the autopsy there was found diffuse peritonitis, the intestinal coils being glued together. Although no bacteriological examination was made, Mr. Page considered that the peritonitis which was present in all these cases was due to the fibrin ferment absorbed from the large haemorrhages, and quoted the opinion of Professor Orth that a considerable quantity of pure blood was sufficient to set up general peritonitis without any micro-organisms being present, owing to the action of the fibrin ferment.

Tavel and Lanz, in their well-known work of 1893, stated that in their opinion those cases of peritonitis which are found to be sterile are really examples of chemical peritonitis, and are due to the products of bacteria rather than to the bacteria themselves. Harvey Cushing, in his masterly monograph on acute diffuse gonorrhoeal peritonitis, has reached much nearer the truth than any other observer. He writes as follows: " Whether chemical peritonitis, so-called, has any actual existence, remains a question of doubt"; and later: " It is possible that some forms of the chemical cases described by the surgeons may be, after all, of bacterial origin." Tavel and Lanz related several cases which they considered to be examples of chemical peritonitis, which are of such interest in view of our results, that we briefly refer to them here.

One was a case of intestinal obstruction, due to a band, of four days' duration. The intestines were reddish brown, and fibrin was present on the surface. There was blood-stained serum in the peritoneal cavity. A pure culture of a white staphylococcus was obtained both from the fibrin and from the serous exudate. Another was a case of acute intestinal obstruction, due to a volvulus, in a man aged sixty. The intestines were enormously distended, and there was a fibrinous peritoneal exudation, from which a pure culture of a white staphylococcus was obtained. The third case was an example of suppurative cholecystitis, with partial gangrene of the wall of the gall bladder. A white staphylococcus was obtained from the interior of the gall bladder in pure culture, although bacilli and chains of cocci were seen in film preparations of the pus. A pure culture of a similar coccus was obtained from the inflamed peritoneum. Two other cases are also reported in their paper, but in both instances cultures from the inflamed peritoneum remained sterile. Although Tavel and Lanz found a coccus in three of their five cases, they preferred to consider that the organism was present as a contamination, and that these were really instances of chemical peritonitis. Gruber and Durham have pointed out that the failure to find microbes in peritoneal fluid is not sufficient evidence to stamp a case as chemical peritonitis, inasmuch as they may be present upon the peritoneal surface and not in the exudate. This we have found to be true in a large number of cases, and attention will be directed to it again when we deal with the peritonitis associated with intestinal obstruction. As we shall show presently, we have found the white staphylococcus not only in intraperitoneal haemorrhage and intestinal obstruction, but also in many other varieties of peritonitis. We, therefore, consider that we have sufficient evidence to justify the opinion that chemical peritonitis does not exist, but that the cases to which the name has been given are really instances of an infection of the peritoneum with the staphylococcus albus. We intend to discuss every important fact in connexion with this coccus after we have considered other varieties of peritonitis. We shall be able to show that this organism is not only important in intraperitoneal haemorrhage, but is the most important organism in the bacteriology of peritonitis.

The changes which ensue as the result of blood extravasation into the peritoneal cavity appear to be similar whatever the source of the haemorrhage, provided that there is no communication either with the exterior or with the bowel. In the traumatic cases the time interval between the onset and the operation was from two to five hours; in the cases of extrauterine pregnancy it varied from twenty-four hours to three months. As we have seen, the only example in which we failed to find a white staphylococcus was a case of ruptured spleen operated upon only two hours after the accident.

We have had examples of every variety of blood extra-

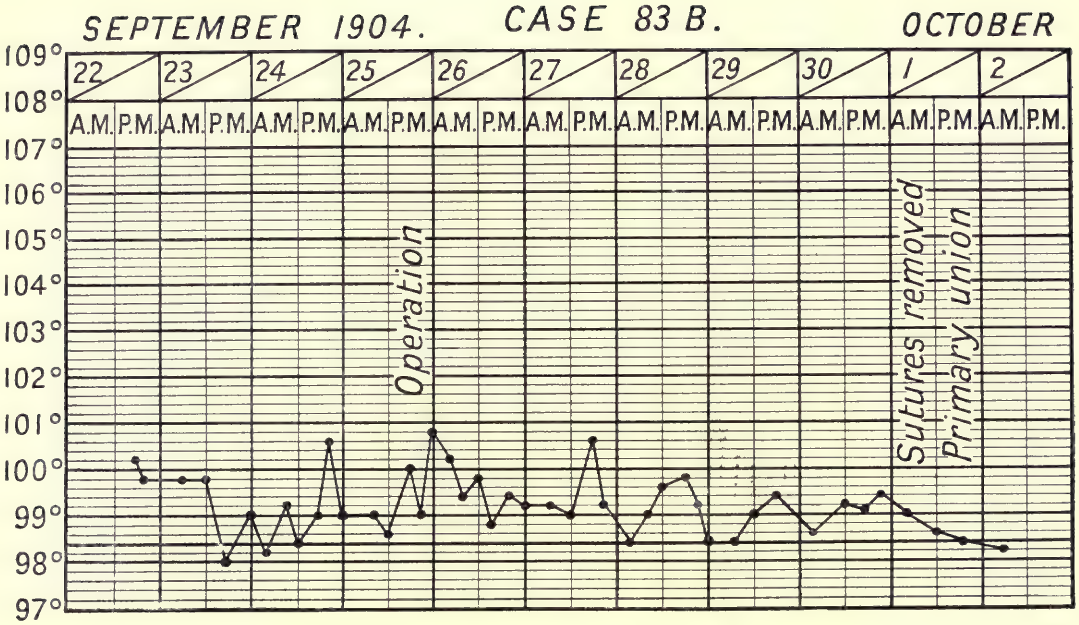


Ruptured Tubal Pregnancy. Operation fifth week. See TABLE I.

vasation, from the recent widespread haemorrhage, down to the old completely encysted haematocele. The appearances on opening the peritoneum vary in degree but not in kind. When the intestines are bathed in blood, even after a very short time, the peritoneum appears reddened, and in the most affected portions the intestines are more or less distended. In the cases where the haemorrhage has been arrested or is only proceeding slowly, these changes are limited to the intestines immediately in contact with the extravasated blood. That peritonitis is present is evidenced by the very fact of the walling off of the haematocele by intestinal agglutination. In every case of haematocele, even the oldest, there was an appreciable quantity of clear or slightly blood-stained exudate in the peritoneal cavity immediately overlying the haematocele, and this fluid in two instances, one of one month's duration, and one of three months, was found to contain the staphylococcus albus, the same organism being also present in the haematocele itself. Of the twenty cases, four proved fatal, two being examples of ruptured tubal pregnancy, and two of haemorrhage from ruptured solid viscera. The fatal cases were all very collapsed when operated upon, and died in a few hours. One traumatic case recovered after splenectomy and peritoneal lavage, and fifteen of the rest after removal of the Fallopian tube and lavage. The abdomen was closed in every case but one, and that was drained *per vaginam.* Thirteen healed by primary union, but one of these became the seat of a late suppuration. In three instances suppuration of the abdominal wound occurred, and from the pus of one of these a pure culture of the staphylococcus albus was obtained.

In cases of ruptured tubal pregnancy a febrile condition is usually present both before and after operation, which is quite independent of local suppuration or of pulmonary or other complications. The temperature charts of the cases which we have examined show a variety of oscillations before as well as after operation, but those occurring after operation are perhaps the more striking. In one instance the temperature had been normal for two days. Vaginal examination under an anaesthetic was followed the same evening by a rise of temperature to 102°. The temperature then became normal or sub-normal for three days, when, after the operation, it steadily rose for five days, reaching a maximum of 101·4°, and then gradually declined for five days more. The wound healed by primary union. Another case had irregular fever, ranging from 99° to 102° for four days before the operation. After operation there was a rigor, followed by irregular fever for nine days. The abdominal wound healed by primary union, but in this instance a vaginal drain was employed for a few days.

The fever lasts for a varying period after operation, and in most cases its range is not excessive, but in nearly every instance it is remarkably higher and more constant than after any other operation which runs an aseptic course. Slight as are the pathogenic properties of the staphylococcus albus, we are of opinion that the febrile disturbances so frequently found after effusion of blood into the peritoneal cavity are due to the presence of this organism, and not to any hypothetical toxic substance produced by the coagulation of the blood.



Ruptured Tubal Pregnancy. Operation tenth day. See TABLE I.

CHAPTER IV

PERITONITIS ARISING FROM INFLAMMATORY DISEASES OF THE FEMALE PELVIC ORGANS

No instance of puerperal peritonitis has come under our notice, but we may accept the statement which has been made by a large number of observers, that many such cases are of "streptococcic origin," and, indeed, clinically they resemble the examples of streptococcic peritonitis, arising from other causes, which we have examined. The peritonitis which arises from a pyosalpinx is of quite a different character, and neither the clinical course nor the bacteriological examination in our cases supports the popular view, namely, that the inflammatory condition in salpingitis favours the development of pyogenic organisms other than the gonococcus, and that it is these organisms which give rise to the peritonitis.

The causal relation of the gonococcus to peritonitis is one which, although difficult of proof, may be considered to have been definitely established. Wertheim, as long ago as 1891, showed that the gonococcus could produce a localised peritonitis in animals; he recovered this organism in pure culture from the sero-purulent exudate, and even went to the extreme length of proving its identity by inoculating it upon the human urethra. Kelly, in 1898, however, stated that in many hundreds of bacteriological examinations he had never been able to demonstrate the gonococcus as the etiological factor in the production of septic peritonitis. In one of his cases " a pyosalpinx had ruptured some days before the operation, and pus containing myriads of gonococci lay free in the pelvis, but there was no peritonitis." In 1899, Cushing published two cases of gonorrhoeal peritonitis which were operated upon and recovered. In both of these gonococci were demonstrated in films of the peritoneal exudate, and from one he grew the gonococcus. No other organisms were found. Hugh Young has also succeeded in cultivating the gonococcus from cases of gonorrhoeal peritonitis. The bacteriological evidence afforded by the few cases in which the organism has been definitely demonstrated by culture methods is supported by many others in which gram-negative intracellular diplococci have been found in films of the peritoneal exudate, but where cultures have remained sterile; and by others, again, of a definite peritonitis dependent upon salpingitis, in which no organisms have been demonstrated, for these cases go at any rate to show that such a peritonitis is not dependent upon any of the easily cultivated pyogenic organisms.

In 1903, Northrup published two cases of peritonitis where the gonococci were found only in the vaginal discharge, and at the same time quoted eight similar instances recorded by Comby. All these ten cases occurred in girls between six and eleven years of age, but a similar case in our series, which will be referred to later, throws considerable doubt upon their nature.

In five out of eight cases examined, cultures from the peritoneal exudate and from the interior of the tubes were found to be sterile, although numerous culture media were employed, namely, broth, agar, and blood agar; and glucose broth for anaerobic cultures. In one case, however, large numbers of diplococci, chiefly intra-cellular, were found in film preparations from the peritoneal exudate and also from the interior of the Fallopian tube. The organism failed to retain Gram's stain, although the morphological characters of the coccus were not absolutely typical of the gonococcus. It is most probable, however, that the organism was the gonococcus, although we failed to cultivate it. This is the only case in which probable gonococci were found. In one case we isolated the staphylococcus albus from a localised intraperitoneal abscess connected with a pyosalpinx. In the other cases we failed to cultivate any micro-organism either from the peritoneal exudate or from the interior of the tubes. This is of interest, owing to the recent views which we have already referred to, namely, that salpingitis is frequently due to the common pyogenic cocci. It is most unfortunate that we failed to isolate the gonococcus in the first case, as the film preparations pointed so strongly to the presence of that organism. Our knowledge of the bacteriology of salpingitis and also of the life history and pathogenic properties of the gonococcus is entirely due to American and Continental workers. Dr. Young has given a full account of the cultural properties of the gonococcus, and he especially recommends the use of hydrocele and ascitic agar for the cultivation of the organism, but unfortunately we did not employ this medium for any of our cases.

We have four examples of diffuse peritonitis spreading from a pyosalpinx. The onset was sudden, but the progress of the symptoms not very acute, the interval between onset and operation being five, ten, fourteen, and twenty days respectively. In two the pulse rate was 120 before operation, with elevation of temperature to 102° ; in the other two the temperature was only slightly above the normal and the pulse was not accelerated. In all there was an odourless peritoneal exudate, clear in three, slightly turbid in one, and in each instance it was distinctly viscid. The peritoneum was reddened in the neighbourhood of the uterine appendages, but there was no intestinal distension, a point of interest in view of the fact that no organism could be cultivated from the exudate. In two of these cases intra-cellular diplococci were seen in the film preparations, but all remained sterile to cultivation whatever medium was employed. The treatment was the same in each instance, namely, removal of the Fallopian tube, lavage of the pelvis with sterile saline solution, and drainage; and all the patients recovered. We consider these four cases to be examples of diffuse gonorrhoeal peritonitis. We also examined a case of diffuse peritonitis arising from salpingitis, in which the gonorrhoeal origin was open to doubt. There had been no symptoms of gonorrhoea, but the uterus had six months previously been curetted for metrorrhagia following a confinement. On admission, there was some rigidity and tenderness in the lower part of the abdomen, the pulse was not accelerated, and the temperature was 100°. The onset had been gradual. On opening the abdomen there was no evidence of peritonitis at the level of the umbilicus, and cultures from this region remained sterile. There were some recent adhesions in the pelvis, together with a quantity of slightly blood-stained fluid. Both Fallopian tubes were acutely inflamed, but not distended nor pus-containing. From the fluid in the pelvis a staphylococcus, not identified, was grown. The Fallopian tubes were removed, and the pelvis was irrigated. Recovery was uneventful.

We conclude that the gonococcus causes a peritonitis which may be diffuse or localised; that it possesses a very slight degree of pathogenicity when introduced into the peritoneal cavity; that although the onset may be sudden, the subsequent symptoms are those of a very mild form of peritonitis; that intestinal distension is usually absent, and that the prognosis is very favourable. We believe the relatively low rate of mortality in these cases to be due, not to any special properties of the pelvic peritoneum, but to the low degree of virulence possessed by the organisms present in the Fallopian tubes. Andrews, in 1904, published the results of bacteriological examinations of the interior of the tube in 684 collected cases of pyosalpinx. The diagnosis in most instances was based upon microscopy only; some upon both films and cultures; and a few upon animal experiments. The result showed 55 per cent. to be sterile, 22·5 per cent. to contain the gonococcus, 6 per cent. saprophytes only, and the rest a variety of pyogenic organisms. It is true that these figures are based largely upon very incomplete bacteriological examinations, and must therefore be received with a good deal of reserve, but they go to show what a small proportion of cases of pyosalpinx constitute any grave danger to the peritoneum.

The peritonitis which arises from a suppurating ovarian cyst is of a very different character, and of these we have examined three cases. In two the lethal organism proved to be the colon bacillus; in the third the streptococcus pyogenes. The first concerned a woman, thirty-five years of age, who for two months had noticed an abdominal tumour, which had been somewhat painful for four weeks. For two days she had been acutely ill, with abdominal pain and vomiting. When admitted she presented all the signs of a diffuse peritonitis; the pulse was 120 and the temperature 100°. Offensive turbid fluid and some gas were present in the peritoneal cavity, and the intestines were red and distended. On one side was a large multilocular ovarian cyst containing clear mucoid fluid; on the other a similar cyst, but gangrenous and containing thick offensive pus. The pedicle was not twisted. Both cysts were removed, and the pelvis was flushed out and drained. Death occurred on the third day. Post-mortem, there was universal peritonitis.

Cover-slip preparations were made from the sero-purulent fluid in the abdominal cavity. Large numbers of degenerated cells were seen, but no micro-organisms. The staphylococcus albus was present in pure culture in the region of the abdomen most distant from the suppurating cyst. The bacillus coli was present alone in the anaerobic cultures which had been made from the sero-purulent exudate. The same type of bacillus was present in pure culture in the contents of both cysts. In this case, therefore, the staphylococcus albus was present in a remote region of the abdomen, whilst the colon bacillus was present in one of the regions of most intense inflammation.

The second case was that of a woman, thirty years of age, who, after an illness of three months, accompanied by vaginal discharge and pelvic symptoms, was seized seven days before admission with acute abdominal pain and sickness. The temperature for five days had ranged between 101° and 103°. When admitted, the pulse was 120 and the temperature 101°, the abdomen was distended and rigid, and a mass was felt per vaginam. On opening the abdomen the intestines appeared normal save for the presence of a few ounces of clear odourless fluid which bathed them. In the left side of the pelvis was a tubo-ovarian abscess, containing thin offensive pus, which, together with a right-sided pyosalpinx, was removed. The pelvis was flushed out and drained. Death occurred from peritonitis on the second day. In this instance the peritonitis was localised, for the clear fluid proved to be sterile. The pus, both in films and cultures, showed only the colon bacillus.

The third case concerned a woman, thirty years of age, who for a fortnight had suffered from slight abdominal pain. Three days before admission she was seized with severe pain and vomiting, and when admitted presented the signs of diffuse peritonitis, with a pulse rate of 120 and a temperature of 100°.

The peritoneal exudate proved to be large in amount, and consisted of offensive purulent fluid. The intestines were everywhere distended and intensely congested, and in places covered with yellowish fibrin. A right-sided ovarian cyst, the size of an orange, had suppurated and burst. It presented a ragged aperture, surrounded by a greenish-black sloughing wall, large enough to admit the finger. The Fallopian tubes were normal. The cyst was removed and the abdomen flushed out and drained, but the patient died within a few hours.

Streptococci and staphylococci were present in cover-slip preparations of the peritoneal exudate, but no bacilli were seen. A pure culture of the staphylococcus albus was obtained from the fluid which escaped when the abdomen was opened, whilst a pure culture of the streptococcus pyogenes was obtained from the purulent fluid and from the surface of the gangrenous cyst. It is most unfortunate that we failed to employ anaerobic cultures in this case, as the peritoneal exudate was most offensive ; but there were no bacilli present in the films made from both the peritoneal fluid and from the gangrenous cyst. We can at any rate exclude the bacillus coli in this case, and one would have expected to find bacilli in the film preparations of the peritoneal exudate, if any such organisms had been present in the abdominal cavity. It is most probable, therefore, that there were no bacilli present.

These three cases present several points of interest. In the first place the colon bacillus may be the cause of a fatal peritonitis arising from a lesion wholly unconnected with the intestinal tract. In one example it was already present in the peritoneal cavity at a distance from the original lesion when the operation was undertaken; in the other there was no diffuse peritonitis at the time of operation, but doubtless the colon bacillus, liberated by opening the abscess, infected the peritoneum. We have seen, and indeed it is a matter of common observation, that local abscesses connected with the uterine appendages are usually dealt with safely by reason of the absence of virulent organisms. If such virulent organisms were more frequently present as in this instance, no doubt the mortality from such pelvic operations would speedily rise.

The third case was one of streptococcus infection of an ovarian cyst, and the resulting peritonitis followed the usual course of a streptococcic peritonitis. In the two cases in which the peritonitis was diffuse at the time of operation, the staphylococcus albus was present in a part of the peritoneal cavity remote from the point of most intense inflammation, and here the intestines were distended. In this respect these cases are strictly comparable to many of the cases of peritonitis arising from other lesions, notably from disease of the vermiform appendix.

It is well known at the present day that it is very seldom that the actual suppuration kills the patient, but it is the situation of the abscess which is so important, and also the degree of virulence of the micro-organism; in fact in the case of some of the most virulent organisms, pus formation never occurs.

We know that the staphylococcus pyogenes aureus may in one case produce a furuncle, whilst in another case a similar strain of the coccus will be the cause of ulcerative endocarditis. Again, the colon bacillus, which is a normal inhabitant of the intestine, may produce a variety of lesions according to the situation in which the bacillus is found. It may be the cause of a slight inflammatory process in a laparotomy wound, as Professor Welch pointed out many years ago ; or it may be the cause of an empyema ; or under certain conditions it may produce emphysematous gangrene, and at any time it may prove to be one of the most virulent micro-organisms known to bacteriologists.

In peritonitis we consider that certain bacilli of the coli group are the most important, the most common, and not infrequently the most virulent of the organisms which are known to cause peritonitis.

When we come to discuss appendicitis we shall find that this view receives little support from the literature of the present day, although it received considerable support in the past. But we have no doubt that it is chiefly due to the colon bacillus that the surgery of acute abdominal diseases still shows such a high death-rate.

CHAPTER V

THE PERITONEUM IN INTESTINAL OBSTRUCTION

THE simplest form of peritonitis arising in connexion with the bowel is that which results from the early stages of intestinal obstruction. We have studied *one hundred* examples of intestinal obstruction from the bacteriological point of view, and have found micro-organisms to be present in almost half the cases. The forty-seven cases of strangulated hernia, which are included in this series, will be considered separately because the mechanical conditions present render it impossible to ascertain the condition of the peritoneum at a distance from the site of the obstruction It has long been known that the fluid in the sac of a strangulated hernia may contain micro-organisms. Nepveau, who in 1867 was the first to assert this fact, stated that he had found micrococci present. In 1886 Garré, in an examination of eight cases, found seven to be sterile and one to contain a coccus which was not pathogenic to animals. In 1889 Clado investigated five examples, of which two proved to be sterile and recovered, whilst three, from which the colon bacillus was obtained, proved fatal. It is interesting to note that this author proposed to base a prognosis upon the bacteriology of the hernial sac, advising that when the colon bacillus is present the prognosis should be reserved, but that if the fluid proves sterile one may pretty confidently say that the patient will recover.

In 1890, Bönnecken found micro-organisms in the fluid, whether clear, bloody, or turbid, on one occasion when the strangulation had existed only four hours. In 1893, Tavel and Lanz, in their classical work on the etiology of peritonitis, investigated twenty-one cases of strangulated hernia. Sixteen proved to be sterile and the other five grew bacilli, but no cocci were found. In 1903, Rodella examined five cases, using both aerobic and anaerobic methods, and found all to be sterile. The total number of such investigations which we have been able to collect, excluding those made post-mortem, amounts to thirty-nine, of which thirty were sterile.

Our own tables include forty-seven cases of strangulated hernia. Cover-slip preparations were made of the fluid in the hernial sac in thirty-three of these cases, in thirty-one of which no micro-organisms were seen; but in one case gram-positive cocci and gram-negative bacilli, and in the other gram-positive cocci only, were found.

In forty-two cases the fluid in the hernial sac was found to be sterile. In five cases micro-organisms were present; in one the colon bacillus was obtained in pure culture; in another the colon bacillus and the staphylococcus albus; in a third case the colon bacillus and a gram-positive staphylococcus.

A bacteriological examination was made from the surface of the intestine in forty-five cases, and was found to be sterile in twenty-nine. On ten occasions a pure culture of the staphylococcus albus was obtained; in one case the staphylococcus cereus albus; in three the colon bacillus; in one the colon bacillus and the staphylococcus albus; and lastly, in one case the colon bacillus and a gram-positive staphylococcus.

Anaerobic cultures were taken on eight occasions, and were found to be sterile, after several days' incubation at 37° C., in seven, whilst in the eighth a pure culture of the staphylococcus albus was obtained.

It will be obvious that a very important point is the frequency with which the staphlyococcus albus has been found on the surface of the intestine, in comparison with its presence in the sac fluid. In no less than ten cases this coccus was isolated in pure culture from the surface of the intestine, whilst we failed, without exception, to find it in the sac fluid. A bacteriological examination of the fluid alone would have led us to the erroneous conclusion that, out of a total of forty-seven cases of strangulated hernia of all classes, no less than forty-two were completely sterile. This alone shows how careful we should be before we make use of terms such as "Chemical Peritonitis" or "Peritonitis Serosa."

Examination of the Omentum in the Hernial Sacs.

A careful report of the condition of the omentum was noted in fourteen cases.

On seven occasions, the omentum was said to be necrotic. In four of these cases, the staphylococcus albus was isolated in pure culture from its surface, and in one case the bacillus coli. That is, in five cases out of seven, micro-organisms were found on the surface of the necrotic omentum. In five cases it was stated to be brown in colour, but in three of these it was found to be sterile, whilst in two the staphylococcus albus was obtained in pure culture. In one case the omentum was only congested, and the cultures were sterile.

In the remaining examples the omentum was either of good colour or no report was given. In just over half the cases, therefore, in which the omentum was stated to be in an abnormal condition, micro-organisms were present.

This is further evidence of the importance of making a complete bacteriological investigation of the contents of a hernial sac before pronouncing it to be sterile.

The Condition of the Intestine in a Hernial Sac and its Relation to Micro-organisms.

The "Congestive Stage."

In thirty cases out of a total of forty-six,[1] the intestines, which were in all stages of inflammation and congestion, were found to be sterile, whilst in eight cases the staphylococcus albus was obtained in pure culture: in one the staphylococcus cereus albus, in one the colon bacillus, and, lastly, in one instance the colon bacillus and a gram-positive coccus.

Necrosis without Perforation.

In five cases, the intestine was found to be necrotic but not perforated. The colon bacillus was isolated in pure culture from one of these cases, the colon bacillus and staphylococcus albus from another, the staphylococcus albus alone in two cases, and in one case cultures were not taken from the surface of the necrotic intestine.

Perforated Intestine.

There was only one example of this condition, and a pure culture of the colon bacillus was obtained both from the sac fluid and from the surface of the intestine.

It is very difficult to explain the result of the bacteriological examination of the inflamed and congested intestine in the hernial sacs. It is possible that if the platinum needle had been drawn over a larger area of inflamed intestine, micro-organisms might have been found more frequently, but even allowing for this, we are unable to advance any sound theory to explain these facts.

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[1] The total should be forty-seven, but in one case cultures were not taken from the surface of the intestine.

The Prognosis of Strangulated Herniae derived from a Bacteriological Investigation.

1. The presence of the colon bacillus in the fluid of a hernial sac increases the gravity of the case.
2. The presence of this bacillus is evidence either of necrosis alone or necrosis with perforation.
3. This organism when present in a hernial sac appears to be able to cause any of the following conditions : Diffuse peritonitis ; suppuration of the wound ; delayed healing accompanied by a low form of inflammation.
4. The staphylococcus albus does not appear to have any obvious influence on the progress of the case.

We consider that positive evidence of the colon bacillus is of great value as regards the prognosis of a case of strangulated hernia, but that negative evidence is of rather less value.

There remain several general considerations which may now be examined. Micro-organisms were present in 33 per cent. ; the staphylococcus albus was found in 23 per cent., and the colon bacillus in 10 per cent. It is well known that as a general rule the proportion of gangrenous cases bears no direct relation to the duration of strangulation of the hernia, because the tightness of the constriction, the presence of a protective pad of omentum, and other circumstances exert a controlling influence. But when examined bacteriologically the time element does appear to be of some importance. In those cases where the strangulation was of under one day's duration, 86·6 per cent. were completely sterile ; between one and two days, 55·5 per cent. ; between two and four days, 50 per cent. ; and over four days, 46 per cent. These figures show a steady decline in the proportion of sterile cases with the increase in length of time of the strangulation. We have also endeavoured to ascertain whether previous taxis had any influence on the bacteriology, but, although it undoubtedly influences the appearance of the gut, particularly with regard to haemorrhage into its wall, yet it seems to bear no relation to the bacteriology of the sac contents.

If the class of hernia is considered, the result as regards the bacteriology is somewhat striking, for from inguinal herniae organisms were obtained in 22 per cent., from femoral herniae in 46 per cent., and from umbilical herniae in 60 per cent.

Examination of the Fatal Cases.

1. Femoral hernia, in a woman aged sixty-six, strangulated seven days. Contained purple small intestine and necrotic omentum. Herniotomy. Death within an hour. The colon bacillus was present both in the fluid and on the gut surface. Post-mortem : diffuse peritonitis.

2. Inguinal hernia, in a male infant, strangulated a few hours. Cultures sterile. Died of erysipelas on the third day.

3. Congenital inguinal hernia, in a young man, strangulated seventeen hours. Taxis under an anaesthetic had been tried before admission. The scrotum was much bruised. The hernia contained a loop of small intestine with much haemorrhage into its wall. Herniotomy. Cultures sterile. Death within twenty-four hours. Post-mortem : no peritonitis.

4. Inguinal hernia, in a male aged forty-five, strangulated five days. Contained congested small intestine. Herniotomy. Cultures sterile. Died from respiratory failure immediately after operation. Post-mortem : no gangrene and no peritonitis.

5. Inguinal hernia, in a male aged seventeen, strangulated thirty-six hours. Contained a loop of small intestine very tightly nipped. The gut was deeply congested and showed greyish patches in places, the thickness of which appeared to consist of little more than peritoneum. The sac fluid was sterile ; the gut surface gave a pure growth of the staphylococcus albus. Resection and axial anastomosis. Death from continued obstruction on the third day.

6. Femoral hernia, in a female aged sixty-two, strangulated twenty-four days. Sac contained blood-stained, offensive fluid, and a knuckle of gangrenous small intestine. Both sac fluid and gut surface gave a growth of the colon bacillus. Resection and axial anastomosis. Death two hours later. Post-mortem : pulmonary embolism. Diffuse peritonitis.

7. Umbilical hernia, in a female aged forty-nine, strangulated seven days. Contained omentum and deeply congested colon. Cultures sterile. Death within twenty-four hours. Post-mortem : no peritonitis.

Of the seven fatal cases, no less than four were sterile and died of causes other than peritonitis. One case in which the staphylococcus albus was the only organism present died of obstruction by kinking at the site of anastomosis, and at the autopsy there was only a little peritonitis immediately around the anastomosis. The two instances in which the colon bacillus was present died almost immediately after the operation, and at the autopsy a condition of diffuse peritonitis was found.

Examination of the Cases in which the Colon Bacillus was present.

These were five in number, of which two have already been mentioned amongst the fatal cases. The remaining three, which recovered, present points of interest in connection with our general conclusions, and are as follows :—

1. A male infant, whose inguinal hernia had been strangulated for twenty-four hours. The intestine presented no more than a slight degree of congestion, but at one spot there was a minute perforation through which was projecting the sharp corner of a fragment of nut-shell. The patch was sequestrated, the gut washed over and returned just within the abdomen, and a gauze drain left in the wound. Suppuration ensued, but there were no signs of peritoneal infection, and the child recovered.

We believe this to have been, not a bacterial necrosis, but a purely mechanical perforation : that the colon bacillus would not otherwise have escaped into the sac ; and that its virulence was not so great as in an ordinary case of necrosis. It is in this manner that we are able to account for the recovery.

2. Inguinal hernia in a male infant, strangulated for twelve hours. The sac fluid was watery and odourless, and the coil of strangulated small intestine was but slightly congested. The gut was washed over and returned, and the canal closed. The child became very ill, and the wound suppurated freely, but recovery ensued. In this case the colon bacillus was present in both cultures, but not in the films of the sac fluid, whilst in addition a gram-staining staphylococcus also was isolated.

3. A male, aged seventy-six, whose inguinal hernia had been strangulated for three days. The sac contained offensive pus, and a loop of colon with a gangrenous, but not

perforated patch. The patch was sequestrated with sutures and the sac drained. The patient recovered, the wound having, of course, suppurated. In this instance the staphylococcus albus was isolated as well as the colon bacillus.

Whenever the colon bacillus was found in a case of strangulated hernia, it was isolated both from the sac fluid and from the surface of the intestine. The staphylococcus albus on the other hand was never present in the sac fluid when it was absent from the peritoneal surface.

The relation of the bacteriology of the sac contents to the healing of the wound is one of interest. Apart from the cases where the colon bacillus was present, the staphylococcus albus was found in pure culture on ten occasions. Not one of these cases suppurated. The three which did suppurate were completely sterile as regards the contents of the sac at the time of operation, so that the suppuration must have been due to extraneous infection.

If the colon bacillus is present, then the probable outcome of the case will be death from diffuse peritonitis, but occasionally, under certain conditions, the result of its presence may be only suppuration of the wound. If the colon bacillus however is not present, then, whatever may be the appearance of the gut, there is no reason, *per se*, why a case of strangulated hernia should suppurate. Whilst we are fully alive to the fallacy of drawing general conclusions from a small number of cases, we consider it to be at least suggestive that not a single case in which the colon bacillus was not present at the time of operation was followed by gangrene, perforation or obvious peritonitis. We use the term obvious because we have shown that peritonitis which exhibits few or no signs, and which is unattended by serious results, is of far more common occurrence than is usually believed. In the prognosis, then, the presence or absence of the colon bacillus is the factor of vital importance, and this observation is of great interest in tracing the rôle which this organism plays in the vast majority of cases of peritonitis arising in connexion with the intestinal tract.

The fifty-three cases of intestinal obstruction other than strangulated hernia consist of :—

	CASES.
Intussusception	14
Carcinoma	14
Impaction of Gall-stones	3
Volvulus	1
Bands and Adhesions	13
Meckel's Diverticulum	2
Congenital Dilatation of Colon	2
Other Causes	4
Total	53

Micro-organisms were present in thirty instances.

If we divide the cases into two periods, taking those of under fifty hours duration in the first, and those of over fifty hours in the second, there is a striking difference in the proportion of sterile cases. Of the nineteen in the first class, only four were sterile, whilst of the thirty-four in the second class, nineteen were sterile. Expressed in percentages, those in the first class, that is to say the most acute, were infected in 79 per cent., whilst those belonging to the less acute class were infected in only 44 per cent. If we consider the situation of the obstruction and divide the cases according to whether the obstruction involved the small or the large intestine, we find that where the small intestine was implicated 63 per cent. were infected, whilst in obstruction of the large intestine only 44 per cent. were infected.

When we consider that by far the largest number of cases of strangulated hernia involve the small intestine, and that, in strangulated hernia there is a steady increase in the proportion of infected cases with the increase in duration of the strangulation, it is obvious that the results derived from intestinal obstruction in general are diametrically opposed to those derived from that particular variety which is produced by the strangulation of an external hernia. Moreover, the total percentage of infected cases in strangulated hernia is only thirty-three, whereas in all other forms of obstruction, taken together, it is fifty-six.

We are of opinion that the more frequent sterility of strangulated herniae is due to the relatively smaller area of intestine available for examination.

Believing as we do that organisms make their way out, not only at the site of most severe damage, but also from all parts of the bowel as it becomes inflamed and distended, we see that with the larger area afforded by the general peritoneal cavity, the more likely are we to find organisms in the general cavity than in the sac of a hernia. Of the bacteriology of the general peritoneal cavity in strangulated hernia we know nothing, but we believe that organisms would be found to be present there just as in other cases of obstruction, were we in a position to investigate the question.

Obstruction of the small intestine has the reputation of causing more acute symptoms than that of the large intestine, and we believe that this is due, partly at any rate, to the fact that peritoneal infection more rapidly takes place from the small than from the large bowel.

Following up our theory to explain why it is that in the less acute cases we find the peritoneum less frequently infected we attribute this to the power which the peritoneum possesses of dealing with the organisms which have appeared in the earlier stages, and indeed the only obstruction cases in which polynuclear cells were seen in the exudate are included in the category of those of over fifty hours' duration. When the obstruction, therefore, is in the general peritoneal cavity, the natural absorptive action of the diaphragmatic peritoneum comes into action, and the more chronic cases are consequently more frequently sterile ; in the case of strangulated hernia, mechanical conditions prevent this from occurring, and therefore the longer the strangulation has existed, the less likely are the contents to be found sterile.

The character of the exudate in intestinal obstruction, from whatever cause arising, is remarkably uniform, although the amount varies considerably. This variation appears to depend upon the acuteness of the obstruction, so far as the quantity can be estimated at the time of operation. As a rule it appears to be most abundant in intussusceptions, which are perhaps the most acute cases in our series. In no case was the turbid fluid observed which will again be referred to in dealing with appendicitis. In the film preparations of the exudate, polynuclear cells were rarely seen, whilst mononuclear and endothelial cells were often present. Micro-organisms were only twice seen in cases where the cultures proved sterile. In these two, polynuclear cells were present, and the organisms were intra-cellular.

The *fourteen cases of intussusception* form a group of particular interest, and will be considered separately.

Cover-slip preparations of the exudate were examined in ten of the cases, and were found to be sterile. It is of interest to note that the polynuclear cells were not seen in the exudate in any of these cases, which is difficult to explain.

Culture tubes were inoculated with the peritoneal exudate in thirteen cases, and found to be sterile nine times. In three instances the staphylococcus albus was isolated in pure culture ; in one, where the intestine was gangrenous, the staphylococcus albus, the colon bacillus, and the bacillus proteus vulgaris were isolated.

A bacteriological examination of the surface of the intestine was made in every instance. In ten, the staphylococcus albus was isolated in pure culture, in three, the cultures remained sterile, and in the remaining case the staphylococcus albus, the colon bacillus, and the bacillus proteus vulgaris were recovered from the surface of the gangrenous intestine.

These observations are further proof of the important part which the staphylococus albus plays in peritonitis and also emphasise the frequency with which the organism is found on the surface of the intestine as compared with the peritoneal exudate. If the results of all the cases of intestinal obstruction are examined,it will be seen that the staphylococcus albus is much more frequently isolated from the surface of the intestine in cases of intussusception than in any other variety of obstruction, and this can perhaps be explained by the more severe pathological changes which occur in the intestinal wall in the most acute as compared with the less acute obstructions. Every case of intussusception was operated upon within a period of forty hours from the first onset of the acute symptoms, with the exception of three cases which had been ill for forty-eight hours, sixty hours, and seven days respectively. In only two instances was the intestine described as gangrenous. In one of these the staphylococcus albus was isolated from its surface, and in the other the colon bacillus was found both in the exudate and upon the intestine. In the third case the peritoneal exudate and the intestinal surface were both sterile at the time of operation, but the patient died from subsequent perforation. Only four of the fourteen cases proved fatal, two from shock, and two from gangrene of the intestine.

The cases of strangulated hernia and of intussusception having been dealt with, there remain *thirty-nine* cases of intestinal obstruction due to other causes. It will be noted that the length of history is greater in most of these cases than in the intussusceptions. Generally speaking, the duration of the illness in intussusception was a question of hours, but in the rest a question of days.

Cover-slip preparations of the peritoneal exudate were examined in twenty-eight cases out of a total of thirty-nine. In four instances gram-positive cocci were seen ; in one gram-negative bacilli ; and in one, gram-positive cocci and gram-negative bacilli.

Culture tubes were inoculated with the *peritoneal exudate* in thirty-six instances, and in thirty the cultures remained sterile. In six cases micro-organisms were isolated, these being in one instance the staphylococcus aureus (from a case of post-operative obstruction which proved fatal) ; four times the staphylococcus albus ; and once the colon bacillus and a gram-positive coccus. In thirty-six cases culture tubes were inoculated from the *surface of the intestine,* of which eighteen were found to be sterile. In the remaining eighteen cases the staphylococcus albus was isolated ten times ; the colon bacillus three times ; the colon bacillus and the staphylococcus albus once ; the colon bacillus and a gram-positive coccus once ; the staphylococcus aureus once ; and the sarcina lutea once.

It will, therefore, be seen that out of thirty-six cases the peritoneal exudate was sterile twenty-nine times, whilst the surface of the obstructed intestine was sterile in only nineteen. If, however, we take the six cases in which the operation was performed within a period of fifty hours after the onset of the symptoms, we find that micro-organisms were present upon the intestinal surface in every one, so that the most acute cases from various causes more nearly resemble, bacteriologically, the acute cases of intussusception.

We may here note that anaerobic cultures were taken on seven occasions, and although the tubes were incubated for several days at 37° C., we failed to find any anaerobic organisms either in the original culture tubes or in the subcultures.

We are now fully able to judge the results which have been obtained in fifty-three cases of the peritonitis which is associated with intestinal obstruction, and of which we give the chief points in a tabulated form.

	Peritoneal exudate.				Intestinal Surface.			
	All cases of Intestinal Obstruction. (1).	Intussusception. (2).	Obstruction apart from Intussusception. (3).	The acute cases of Intussusception. (4).	(1) ditto.	(2) ditto.	(3) ditto.	(4) ditto.
No. of cultures examined .	49	13	36	5	50	14	36	6
No. sterile	39	9	30	3	22	3	18	0
No. of cases in which micro-organisms were found .	10	4	6	2	28	11	18	6
No. of cases in which the staph. albus was isolated by itself	7	3	4	1	20	10	10	3
No. of cases in which the staph. albus was isolated with other organisms . .	1	1	0	0	2	1	1	0

Analysis of the Fatal Cases.

Of the fifty-three cases of intestinal obstruction from causes other than strangulated hernia, twenty-two died.

Of these, ten were completely sterile at the time of operation. We may rule out of account those that died of causes other than peritonitis, which are seven in number.

Three cases, sterile at the time of operation, one an intussusception, one a carcinoma of the caecum, and one a gallstone impaction, died of peritonitis. In the case of the intussusception the peritonitis was due to subsequent perforation. In both the other examples the obstructed bowel had been opened during the operation, and doubtless the peritoneum had received its fatal inoculation by that means. The explanation lies in the exalted virulence of the organisms present in obstructed bowel. Operations of resection or of short circuiting performed during the existence of acute obstruction are attended by a higher death rate than when done in a condition of intestinal repose. E. M. Corner has expressed the belief that the leakage of an anastomosis is not due to imperfect suturing so much as to infection along the stitches, and this view is upheld by the bacteriological facts. It is, therefore, on bacteriological grounds, as well as on those of practical experience, that one should as far as possible avoid the opening of the intestine during acute obstruction. If it becomes necessary to empty the coils of bowel in order to be able to proceed with the operation, grave additional risk is run. If resection or colotomy have to be performed, they should be rendered as far as possible extra-abdominal manœuvres by appropriate suturing and packing.

In six of the fifty-three cases of obstruction, the colon bacillus was present in the peritoneal cavity at the time of operation, and of these not one recovered, death occurring in from a few hours up to the third day, with one exception in which the fatal issue was delayed until the eighth day. This exception is of great interest. It was a case of carcinoma of the colon in a woman of fifty, whose obstruction had been chronic for six weeks and acute for several days. The staphylococcus albus and the colon bacillus were isolated from the intestinal surface, and the staphyloccoccus albus alone from the exudate at a distance. There was a minimal amount of clear fluid present, whilst the intestines were greatly distended and reddened. Colotomy was performed. Death took place on the eighth day, and at the autopsy there was found a condition of universal peritonitis.

Prognosis.

We doubt whether a prognosis of much value would be derived from examining film preparations of the peritoneal exudate in cases of intestinal obstruction. All that we can say with any feeling of security is that positive evidence of the presence of the colon bacillus in the general peritoneal cavity affords sufficient ground for giving an extremely grave prognosis. Negative evidence, however, is of rather less value, because it does sometimes happen, although rarely, that the colon bacillus makes its appearance after the obstruction has been relieved, as in one of our cases of intussusception. If the intestine has been opened during the operation, then the bacteriological examination of the peritoneum is of no value whatever in indicating the probable termination of the case.

CHAPTER VI

INFLAMMATION AND PERFORATION OF THE HOLLOW VISCERA.

UNDER this heading we include the gall-bladder, stomach, duodenum, and the intestines, with the exception of the appendix vermiformis, which will be considered separately.

Cholecystitis and Perforation of the Gall-Bladder.

With regard to the gall-bladder, it is difficult to form an opinion as to the bacteriology of peritonitis arising from this cause, owing to the scantiness of the material at our disposal. Recently J. T. Hewitson has published his results of the examination of bile obtained from cases of cholelithiasis at the time of operation. He investigated nineteen such cases, of which only three proved to be sterile. In the remaining instances the colon bacillus was found eight times, the streptococcus pyogenes four times, other cocci nine times, and other bacilli four times. He also tested the action of sterile bile upon a variety of pathogenic organisms, and concluded that it possesses no antiseptic property whatever. Naunym, Gilbert, Girode, Dupré, and others, have found normal bile to be sterile. One of us recently found ten c.c. of bile, taken from the gall bladder at an operation for supposed cholecystitis, to be sterile under both aerobic and anaerobic conditions.

Fraënkel reported a case of perforation of a diseased gall-bladder, where the staphylococcus albus and the streptococcus pyogenes were found in the peritoneal exudate.

Only two instances of cholecystitis are included in our series.

The first case occurred in a man, aged sixty-eight. This patient had had a history of gall-stones for many years. He had been very ill for seventeen days before admission, with abdominal pain and fever. When admitted the temperature was 101°. A small localised collection of necrotic material was found outside the gall-bladder, communicating with the interior by a perforation over a stone. There was a quantity of sticky purulent, bile-stained fluid around the stones in the gall-bladder. The peritoneal cavity at a distance was found to be sterile. A pure culture of a streptococcus was obtained from the necrotic material around the gall-bladder, and also from the interior of that viscus. The organism resembled the streptococcus pyogenes in most of its cultural characters, but, although several tubes of litmus milk were used, it failed in every instance either to acidify the litmus or to thicken the milk. When the coccus was injected into the vein of a rabbit's ear, no local erysipelas resulted, and although the animal was ill for several days it finally recovered. The same organism was non-pathogenic to guinea-pigs. This coccus may have been an attenuated pyogenic streptococcus, or a different organism. We are not justified, however, in describing it as the streptococcus of Rosenbach. The patient recovered.

The second case concerned a woman aged thirty-five, suffering from empyema of the gall-bladder. The peritoneal cavity was sterile. The thick white odourless pus in the gall-bladder gave a pure culture of the colon bacillus, and the films showed only gram-negative bacilli, together with large numbers of degenerated polynuclear cells. The patient recovered.

PERFORATION OF THE HOLLOW VISCERA

Perforated Gastric Ulcer.

A well-known physician once said, that "where facts are barren, theories are numerous." It would be difficult to find a more suitable illustration of this truth than that afforded by perforating ulcer of the stomach. It is, however, only with reference to the peritonitis produced by this accident that we are at present concerned.

Very little work has been done upon the bacteriology of gastric perforations. J. T. Hewitson, from experiments made with gastric contents taken during operations, concluded that in half the cases the contents of healthy stomachs are sterile, and that in the other half either the organisms present are non-pathogenic, or their degree of pathogenicity is extremely low. In diseased conditions, however, the percentage of sterile cases is lower, but neither in the stomach, nor in the exudate in cases of gastric perforation, did he describe an organism resembling the one which was present in every one of our cases.

Lately, owing to the work of Ghon, the pneumococcus has been credited with an important share in the causation of gastric perforation. This observer reports four cases which, however, are not as fully described as one would wish when we consider the important bearing which this communication must have on future work. It is significant that only one of these instances of perforation of the stomach was due to a simple ulcer. His cases are as follows:

Case 1. Perforated ulcer of the stomach in a girl aged twenty-three. The patient died on the fourth day of the illness from diffuse peritonitis. Cultures from the peritoneal exudate gave a pure growth of the pneumococcus. The coccus was found to be non-pathogenic to white mice; it did not appear to be capsulated.

Cases 2 *and* 3. Diffuse peritonitis; in each case due to a perforated gastric carcinoma. In both instances, the pneumococcus was stated to be present in the peritoneal exudate. In the third example, the organism was proved to be pathogenic to mice. This patient also had pneumonia.

Case 4. Peritonitis associated with meningitis, and gastric carcinoma without perforation. The pneumococcus was found both in the peritoneal and meningeal exudate.

In all these cases the report of the bacteriological investigation leaves much to be desired. In two of the four cases, the patients were found to have well recognized pneumococcic infections apart from peritonitis.

Jensen is stated to have isolated the pneumococcus from the peritoneal exudate in three cases of perforated gastric ulcer. Brünner collected twenty-two cases of perforated gastric ulcer which had been examined bacteriologically, and found that four were due to the pneumococcus.

Other observers have claimed, but with insufficient evidence, that "streptococci" and "staphylococci" are the cause of the active changes which take place in the stomach wall.

It will thus be readily seen that the bacteriological investigations of this very important disease and of its most important complication have been found to be of little value. It is, therefore, with a feeling of some reserve that we bring forward our results. This investigation has led, however, to most constant results. We have isolated a *strepto-diplococcus* from the edge of the ulcer in every case; and from the peritoneal exudate in four instances out of a total of seven. We have also obtained this same organism from the pleural sac and from the sub-phrenic abscess following on perforated gastric ulcer in which the strepto-diplococcus had been isolated; and also from a perigastric abscess. A full account of this research will now be given, and although it is not our wish to suggest that this organism which has been found in every case, without exception, is the cause of the disease, yet, we do claim that these results are of considerable importance and will serve as a basis for future work.

Case 1.—Male, aged thirty-two. About a couple of drachms of thick white odourless pus escaped from a perigastric abscess. The peritoneal cavity was not opened. Film preparations of the pus from the abscess showed large numbers of polynuclear cells and diplococci, and short chains of diplococci which were gram-negative. A pure culture of the *strepto-diplococcus* was obtained from the contents of the abscess.

Case 2.—Female, aged twenty-one. Acute symptoms had lasted twenty-four hours. A large quantity of viscid, clear, but slightly greenish fluid was present in the peritoneal cavity. Large numbers of polynuclear cells were found in the peritoneal exudate. A few diplococci were also seen, but these were entirely intra-cellular, and did not stain by Gram's method. A pure culture of the *strepto-diplococcus* was found in the peritoneal exudate, and the same organism with the staphylococcus albus from the edge of the ulcer. There was very little evidence of peritonitis at the time of operation, and the patient made an excellent recovery.

Case 3.—Male, aged thirty-two. Perforation had occurred six hours before operation. A fair quantity of milky fluid escaped from the peritoneal cavity at the operation. There was only a very slight degree of peritonitis. The man made an excellent recovery. We failed to observe any organisms in the peritoneal exudate although numerous polynuclear cells were found. A pure culture of the *strepto-diplococcus* was obtained, both from the fluid in the peritoneal cavity and from the edge of the ulcer.

Case 4.—A female, aged twenty-three. Perforation had occurred fourteen hours before operation. There was a good deal of turbid fluid and free gas in the peritoneal cavity. The peritonitis appeared to be only of slight degree. Cover-slip preparations were made of the general exudate. Numerous polynuclear cells and cocci, diplococci, and short chains of strepto-diplococci, which did not stain by Gram's method were present. A pure culture of the *strepto-diplococcus* was obtained from the peritoneal exudate and from the edge of the ulcer.

Case 5.—Female, aged nineteen. Perforation had occurred twenty-four hours before operation. There was a large quantity of turbid fluid present in the general cavity; the intestines were distended and reddened, and there was marked evidence of diffuse peritonitis. The patient died a few hours after the operation. Numerous polynuclear cells were met with in the peritoneal exudate, but no micro-organisms. The *strepto-diplococcus* was isolated from the general exudate, and the colon bacillus and the coccus from the edge of the ulcer.

Case 6.—Male, aged twenty-seven. A considerable amount of green turbid fluid was present in the general cavity, but no gas. The acute symptoms occurred thirty-two hours before the operation. The patient recovered.

Film preparations of the exudate were unfortunately omitted in this case. A pure culture of the *strepto-diplococcus* was obtained from the peritoneal exudate and from the edge of the ulcer.

Case 7.—Female, aged twenty-five. A considerable amount of gas and turbid fluid were present in the general cavity. The perforation had occurred nineteen hours before operation. Only slight evidence of peritonitis was found.

Polynuclear cells were numerous in the peritoneal exudate, and also gram-positive diplococci. The turbid fluid from the general cavity was found to be sterile, but the *strepto-diplococcus* and the staphylococcus albus were obtained from the edge of the ulcer, and from the peritoneal surface of the stomach. The patient did well for ten days, but eventually died of septic pneumonia.

Case 8.—Male, aged fifty-seven. Perforation occurred twenty-eight hours before operation. There was a large amount of turbid fluid and free gas in the peritoneal cavity. The patient made a complete recovery. Numerous polynuclear cells and gram-positive cocci were present in the peritoneal exudate. The fluid in the general cavity was found to be sterile, but cultures from the edge of the ulcer and from the peritoneal surface of the stomach gave a growth of the *strepto-diplococcus* and the staphylococcus albus.

Case 9.—The patient (Case 4 above) developed a subphrenic abscess nearly a month after the operation for perforated gastric ulcer. Thick cream-coloured non-offensive pus was present in the abscess cavity. The *strepto-diplococcus* and the staphylococcus albus were isolated from the abscess cavity and from the surface of the pleura. The patient died at a later date from portal pyaemia.

We are now in a position to discuss this organism which has been found in every case of perforated gastric ulcer. The following is a full account of its morphology, staining properties, and pathogenicity.

Morphology.

This coccus occurred, both in the films of the exudate and in the various media, but more especially broth, in the form of a diplococcus, and also in chains of eight or ten cocci or diplococci, whilst not infrequently twenty, thirty and forty cocci helped to form a chain. We have described the coccus as a diplococcus because it was much more frequently found in the form of a diplococcus, than as single coccus. We did not observe a capsule on any occasion. The organism was non-motile.

Staining Reactions.

This coccus in the large majority of cases, whether obtained direct from the patient's tissues or from artificial culture media, failed to retain Gram's stain. In one or two instances it was found to stain slightly by Gram's method, but a true positive reaction was not seen. The coccus stained well with the aniline dyes.

Cultural Characters.

Agar.—In every case the organism grew well on the surface of agar. The colonies were always small, about the size of an active streptococcus colony. They appeared to be about the size of a pin's point, even after several days' growth, and formed opaque, delicate, quite isolated colonies, with no tendency to form a continuous streak. They were faintly granular, and had a regular margin.

Broth.—The growth in this medium was of the same character in every case, namely, sandy deposit, but quite clear above. When the broth tube was shaken, a distinct, but finely granular deposit was visible.

Litmus milk.—This medium was acidified in either forty-eight or seventy-two hours, and remained acid at the end of one month from the date of inoculation. No thickening or clotting occurred in most cases even at the end of a month's incubation. In two instances (59A and 74A), however, the milk thickened at the end of forty-eight hours, and a distinct clot formed in eight days in the former example.

Jelly.—In three instances (74A, 59A, 4B) a surface growth was noticed on the jelly media. In each case there was a very fine pinpoint growth, forming isolated points with no tendency to coalesce. The medium was not liquefied, even at the end of one month's incubation at 22°C. The colonies were almost transparent.

Neutral red jelly.—The colour of this medium was unaffected.

Potato.—No growth was obtained.

Glucose broth (Anaerobic).—In those cases in which anaerobic methods were used the growth appeared to be similar to the aerobic growth.

Pathogenicity.

A twenty-four hours' broth culture was used for inoculating guinea-pigs and mice, either subcutaneously or intra-peritoneally. We failed to kill any of these animals with this organism. In many cases the animals were extremely ill, but death never occurred, and we did not observe any pathological lesion at the autopsies on animals which had been inoculated with the culture of this coccus and killed later.

Agglutination Tests.

In only one instance (75B) was the agglutination test found to be of any value. In this case well marked agglutination was obtained with a dilution of 1 in 10 and 1 in 20 within 30 minutes, and a slight reaction with a dilution of 1 in 50.

We have given the chief points which have been investigated, so far, as regards this organism. We hope, however, to be able to give at a later date a more detailed description of this coccus which we have found in cases of perforated gastric ulcer.

Has this organism any relation to the streptococcus pyogenes, pneumococcus, or other known pathogenic organism ?

It is quite evident that this coccus has very low pathogenic properties in the human being, in the large majority of cases. It is found—as we have shown—in the peritoneal cavity in cases of perforated gastric ulcer, and yet the patients did not die of peritonitis. It is true that it was found in the pus from a case of sub-phrenic abscess in conjunction with the staphylococcus albus, but the peritoneum seems to be able to deal with this organism, as with other organisms, better than the tissues. One would imagine that this coccus is sufficiently pathogenic in the human tissues to produce the well-known ulcer of the stomach, as we have found it in every case at the edge of the ulcer. There is not, however, sufficient evidence from our investigation to warrant this view, although one would not expect a streptococcus or any other organism to be present in every case if it had nothing to do with the disease. In sections of the stomach wall around the site of perforation of an ulcer, large masses of cocci can be seen, and also diplococci, but no true streptococci. Several observers have drawn attention to the presence of cocci in the gastric wall in cases of ulceration, but it by no means follows that these organisms are, therefore, the cause of the condition.

The nature of the strepto-diplococcus.—It must be evident from the points to which we have drawn attention in the life history of this coccus, that its cultural properties are not constant in every case. This, however, is common to most micro-organisms, but on the whole, the morphology, cultural characters, staining properties, and pathogenicity are fairly regular. It is now generally recognized that various cocci which have been described by various authors as the streptococcus pyogenes are really nothing more than streptococci, and not the true coccus of Rosenbach. The same may be said of the pneumococcus, and also of many other micro-organisms. The streptococcus which we have described, however, differs in so many respects from the streptococcus pyogenes, that it would be impossible for any one to consider the two micro-organisms as one. In the first place, it was gram-negative. The constant tendency to form a diplococcus arrangement is quite unlike the streptococcus pyogenes. The organism resembled the streptococcus pyogenes in the fact that it did not alter the colour of neutral red jelly. We, however, failed to employ the various sugar broths which have been shewn by Gordon to be so valuable in the classification of the various streptococci. The pathogenic properties of streptococci certainly vary considerably. A streptococcus which has produced severe changes in human tissues may be found to have very little effect when inoculated into a susceptible animal. We failed to find any evidence of erysipelas at the site of inoculation in our animals. As already stated, this strepto-diplococcus failed to kill, although in almost every case the animal was ill for some hours after the inoculation. There is one point which is quite certain, that if this coccus were really identical with the streptococcus pyogenes, the perforation of a gastric ulcer would be followed by almost certain death. There is no need to discuss the relationship of this organism to the pneumococcus, as they differ perhaps even more than in the case of the streptococcus pyogenes. We are, therefore, inclined to allow this strepto-diplococcus to remain unclassified.

In six cases the peritoneal cavity was flushed out after suture of the ulcer, and in one practically no washing was done. This last case had been perforated twenty-four hours, the small aperture was closed with lymph at the time of operation, and the signs of peritonitis were slight. No drainage was employed, and the wound healed by primary union.

Recovery took place in five instances (though one died a month later of portal pyaemia) the wound in the two cases where drainage was not employed having healed without suppuration. Two patients died, one on the tenth day from pneumonia, but without any peritoneal symptoms, and the other of diffuse peritonitis soon after the operation. This last was the only case in which the colon bacillus was found, and at the autopsy there was present a condition of universal peritonitis which exhibited the peculiar sticky exudation seen in the peritoneal cavity of guinea-pigs killed with this organism.

As in the case of acute perforations, so it is with localized abscesses dependent upon gastric ulcer. In one instance there was a local perigastric abscess, adherent to the anterior abdominal wall, in a man aged thirty-two, who, after a long history of gastric symptoms, had been rather acutely ill for a fortnight before operation. The thick, odourless pus showed the same strepto-diplococcus to be present. In another example, a left-sided subphrenic abscess was opened twenty-five days after operation for an acute perforation. The pus was odourless, thick, and cream-coloured, and had to be reached through the diaphragm. Both the pleural sac, which was inflamed and moist, and the abscess, gave a pure culture of the strepto-diplococcus, which, both in the peritoneal exudate and in the edge of the ulcer, had been found at the first operation. This patient subsequently died of portal pyaemia.

In the gastric ulcer cases the operation was undertaken at times varying from six to thirty-two hours after perforation. In all there was a large amount of fluid in the peritoneal cavity, which was thin, turbid, and sour-smelling. In two examples it was distinctly greenish ; in one, where the perforation was minute and closed by lymph, the fluid was quite clear, and sticky. The intestines were usually reddened, but very little distended ; what signs of peritonitis were present were usually only at all obvious in the immediate neighbourhood of the perforation, where flakes of lymph were commonly seen. The only instance in which the peritonitis was observed to be at all extensive, and in which intestinal distension was marked, was the instance in which the colon bacillus was found, and which succumbed to peritonitis.

This is further proof of the great importance of the colon bacillus in peritonitis. It is also of interest that although this bacillus was isolated in this instance, the strepto-diplococcus also was present. We should expect, if certain theories were correct, that the bacillus would have outgrown the coccus.

Perforated Duodenal Ulcer.

In these cases we find a bacterial condition rather different from that obtaining in the gastric cases. In the four examples in our series, the perforation was situated in the first part of the duodenum, and the appearances afforded by the peritoneum and the exudate were similar to those seen in the gastric cases. In no instance, however, was the strepto-diplococcus isolated from the exudate, which was sterile in three cases and contained the colon bacillus in the remaining one. The gut surface once showed the staphylococcus albus ; on two occasions the staphylococcus albus was isolated from the edge of the ulcer, and once the colon bacillus together with the strepto-diplococcus. The time that had elapsed between onset and operation was in two instances four hours, in one nine hours, and in the fourth nineteen hours. In every case the ulcer was sutured and the abdomen washed out. Two recovered, one with, and one without drainage, and in both instances the wounds healed kindly. Of the two fatal cases, one succumbed to pneumonia on the third day, but with a healthy peritoneum ; the other died of diffuse peritonitis, and this was the one example in which the colon bacillus was present in the peritoneal exudate; the perforation had occurred nineteen hours before operation. In this instance a large quantity of turbid, sour-smelling fluid, and some gas were present in the peritoneal cavity. Large numbers of polynuclear cells and gram-negative bacilli were present in the exudate. The colon bacillus was found in pure culture in the exudate and the same organism together with the strepto-diplococcus in the edge of the ulcer. The coccus was not fully worked out in this case.

Perforation of the Jejunum.

We mention separately one remarkable intance of perforation of a peptic ulcer of the jejunum, which occurred twenty-two months after gastro-enterostomy for simple gastric ulcer. The patient was a male thirty years of age, and the acute symptoms had been present for four hours before the operation. A large quantity of clear odourless fluid was free in the peritoneal cavity, and there was a small perforation in the jejunum close to the anastomotic opening, around which the peritoneum was reddened and covered with flakes of fibrin. Elsewhere there was scarcely any sign of peritonitis. The exudate showed large numbers of degenerated cells and a few polynuclear cells, but no organisms. From three situations, namely the exudate, the edge of the ulcer, and the surface of the jejunum, the staphylococcus albus was obtained in pure culture. The ulcer was invaginated, the abdomen was flushed out, and the pelvis drained. The patient recovered.

Perforation of the Ileum.

In this class there are four examples, one being due to a bullet wound, one to a chronic ulcer of undetermined nature, and two to typhoid ulcers. The gunshot wound of the ileum occurred in a healthy boy aged eighteen, who was operated upon twenty hours after the accident. There was a little bloody exudate amongst the slightly reddened but not distended coils of small intestine. Two minute perforations and three bruises were found in the ileum about three feet from the ileo-caecal valve, the wound of entrance having been situated through the right rectus muscle at the level of the umbilicus. Before operation the only signs of intra-abdominal injury were slight tenderness round the wound, and a steadily accelerating pulse-rate, which reached 120 before operation. The surface of the intestine at a distance was found to be sterile ; the blood-stained fluid around the perforations showed only blood microscopically, and gave a pure growth of the staphylococcus albus. The perforations were closed, the intestines in the neighbourhood were washed over with sterile saline solution, and the abdomen was closed without drainage. The wound healed by primary union.

We regard this case as forming a link between those of intra-peritoneal haemorrhage without intestinal lesion on the one hand, and perforations due to disease on the other. In the former there is no intestinal perforation, in the latter the contents of the perforated intestine are in a state of exalted virulence, whilst in this instance the intestine was in an absolutely healthy condition when the perforation took place.

The difference in prognosis in perforation of the intestine according to whether the bowel is or is not diseased at the time of perforation, is obvious when we look at the mortality of the two conditions. In diseased conditions, perforated appendix or typhoid ulcer for instance, the mortality is not less than 70 per cent., but in gunshot wounds in civil practice, of which we have collected fifteen cases from various sources, the mortality was only 20 per cent. It is only fair to say, however, that these cases are usually operated upon earlier, but this fact would scarcely make the difference between 20 and 70 per cent.

Perforated Chronic Ulcer of the Ileum.

A man, aged twenty, had suffered from abdominal pain and vomiting for thirty-six hours. Abdominal section was performed, and a large quantity of dark, odourless fluid escaped, from which both aerobic and anaerobic cultures were taken. A large perforation of the ileum was found at the base of a chronic ulcer. There was diffuse peritonitis present. The intestines were distended, reddened, and covered all over with fibrinous lymph. The fluid around the ulcer had a smell similar to that of the ordinary appendix pus, although nothing like true pus was found. The ulcer was excised and the peritoneal cavity was washed out with normal saline, but the patient died the following day.

Enormous numbers of polynuclear cells were seen in the peritoneal exudate, some of which were degenerated, but mostly in good condition. No micro-organisms were seen.

Cultures were made under aerobic and strict anaerobic conditions. Weil's medium was completely decolourised in twenty-four hours. A minute gram-positive coccus, a diplococcus, and a short chained streptococcus were present in both the aerobic and anaerobic culture tubes. The colonies on the surface of agar were delicate, moist, greyish coloured, granular, and with a regular margin. No gas formation occurred in glucose media. The coccus formed a delicate, but continuous white streak on the surface of an agar slope; it formed a sandy deposit in broth and the upper layers of the medium were clear; it acidified litmus milk in twenty-four hours, and formed a slight clot in forty-eight hours, which was re-digested in four days; neutral red jelly was liquefied in eight days and the medium was by this time of a golden brown colour; a very slight white streak appeared on the surface of potato, which did not become more extensive in course of time. The patient's serum had no agglutinative effect on this coccus. The organism was injected into the peritoneal cavity of two guinea-pigs, and also into the subcutaneous tissues. Although all the animals became very ill, none died, and we failed to observe suppuration in any case. There was a considerable swelling in the subcutaneous tissues all around the site of inoculation, which was very hot and tender, and took several days to subside.

Whether this coccus was the cause of the peritonitis it is impossible to be certain, but it seems highly probable. It was the only organism present in the peritoneal exudate or on the surface of the inflamed intestines, at least as far as our aerobic and anaerobic cultures show. It appears, as far as we know, to be an unclassified coccus. That the colon bacillus was not present in the peritoneal cavity in this instance is of considerable interest.

Peritonitis in Typhoid Fever.

The rôle of the bacillus typhosus in peritonitis is a very doubtful one. Curschmann believes that cases of peritonitis without perforation sometimes occur during attacks of enteric fever and are characterised by mild onset, irritative symptoms in the right iliac fossa, and perityphilitic exudation; and that the course of such cases is relatively favourable. He quotes a case of Murphy's in which there was peritonitis without perforation, and five cases reported by Gardner in which a fatal peritonitis occurred without perforation. The Munich autopsies shew that peritonitis without perforation occurs in 2·2 per cent. of the fatal cases. Cushing also, believing that a localised peritonitis may occur without perforation, considers such a condition to constitute a pre-perforative stage. But of the bacteriology of non-perforative peritonitis in typhoid fever we know nothing.

Much of our knowledge of typoid fever, at the present day, is derived from the work which has been done at the school of Baltimore.

Harvey Cushing published his excellent monograph on "Intestinal perforation in typhoid fever" in the Johns Hopkins' Reports, in 1898. We shall refer to the chief points in this paper before giving the details of our own work. His cases are as follows:—

Case 1.—The peritoneal cavity was opened four hours after the first symptoms of perforation had occurred. About 200 c.c. of sero-purulent fluid escaped, chiefly from the pelvis. Cover-slip preparations of the fluid showed large numbers of polynuclear cells, but no organisms. A small perforation which was found in the ileum, was sutured. Many thin ulcers were seen at the time of operation. Cultures taken from the peritoneal exudate were found to be sterile.

A second operation, for the relief of symptoms pointing to perforation, was performed, but no fresh perforation was found. There was no fluid present, and the cultures from the peritoneal cavity remained sterile. Thirty-four hours after this operation, the patient developed acute intestinal obstruction, due to adhesions around a second perforation. The obstruction was relieved and the perforation was sutured. Culture tubes which were inoculated with the exudate from the site of obstruction gave a growth of the colon bacillus, the bacillus proteus vulgaris, the bacillus lactis aerogenes, and an organism culturally closely akin to the bacillus typhosus. The convalescence was tedious, but the patient eventually recovered.

Case 2.—Intestinal perforation in the fifth week of typhoid fever. Diffuse peritonitis at the time of operation. Three perforations in the ileum were sutured, but death occurred on the operating table. Cover-slip preparations of the peritoneal exudate shewed numerous cocci, but mostly bacilli, and a large number of pus corpuscles. No streptococci were seen. A pure growth of the colon bacillus was obtained. Dr. Cushing, however, does not attach much importance to the presence of this organism in the peritoneal cavity. He says, "Undoubtedly the colon bacillus being more in evidence is frequently held responsible for peritoneal infection due to more virulent but culturally less vigorous organisms." We shall have occasion to criticise this statement at a later period of this work.

Case 3.—Perforation at the end of the fourth week of typhoid fever, after prolonged abdominal symptoms. The perforation was sutured but death took place eight hours after the operation. The streptococcus pyogenes, and the colon bacillus were isolated from the peritoneal exudate. At the autopsy, a pure growth of the colon bacillus was obtained from the liver, kidney and a mesenteric gland. The bacillus typhosus was isolated from the spleen and gall-bladder, and the streptococcus pyogenes from the peritoneal cavity. This case, perhaps more than any which has yet been recorded, serves to illustrate one of the most important points in the bacteriology of peritonitis. Dr. Cushing, whilst discussing the previous case of peritonitis, stated what perhaps is the most popular belief in medical literature—that the colon bacillus grows so rapidly that it is held responsible for the large majority of cases of peritonitis which are really due to more virulent but culturally less active organisms. The example of streptococcic peritonitis to which he had just previously referred in his paper is a direct contradiction of this statement. We might describe this case as a practical proof against a popular theory. We have still a remarkable fact to record in this example of peritonitis. The streptococcus pyogenes and the colon bacillus were isolated from the peritoneal cavity at the time of operation, but the streptococcus alone at the autopsy—a reverse order of things. This case, therefore, must be one of the most extraordinary yet recorded.

We shall have to refer more fully to these valuable observations of Dr. Cushing's when we come to discuss the peritonitis of streptococcic origin.

The typhoid bacillus has been obtained from the peritoneal exudate in perforative typhoid ulcer both by Flexner and Hays; from an example of diffuse peritonitis due to a suppurating mesenteric gland by Körte; and Klein is said to have isolated the typhoid bacillus from the peritoneal exudate in a case of localised peritonitis. These cases appear to be the few recorded, if not the only, examples of peritonitis from which the typhoid bacillus has been isolated. We must remember that a bacteriological examination of the peritoneal cavity in perforative typhoid ulcer has only been made in a few of the great scientific medical schools in America and on the Continent, if we are to judge by the literature. Keen states, in his book on the Surgery of Typhoid Fever, that he only knew of a single instance in which a bacteriological examination was made of the contents of the peritoneum in typhoid perforation. In 1902, seven cases of typhoid perforation were recorded at a meeting of the Clinical Society of London, but a bacteriological examination of the peritoneal exudate was omitted in every case.

Hays reported two such cases, finding the bacillus typhosus in one, and the streptococcus pyogenes in the other. Both patients died. Manahan investigated two cases at the time of operation. In one, ten hours after perforation, the films were sterile, and the cultures showed only the colon bacillus. The typhoid serum reaction was positive, and the patient recovered. In the second case, the staphylococcus albus and the colon bacillus were isolated from the cultures. The patient died. Varvachi investigated six cases, but all post mortem ; all showed the colon bacillus and none the bacillus typhosus.

We are able to record two cases of typhoid perforation in which we have made a complete bacteriological examination of the peritoneal exudate, as far as it was possible to do. We have used the phrase " as far as possible," because surgeons usually perform a comparatively limited operation for this complication of typhoid fever, and, therefore, it is generally impossible to make cultures of the peritoneal exudate at a distance.

Case 1.—Boy, aged eight. About two ounces of turbid fluid escaped from the incision in the peritoneum, and also a very small quantity of gas. A perforation which was found about four inches from the ileo-caecal valve, was invaginated. The intestines were uniformly pink, but not much distended.

Large numbers of polynuclear and mononuclear cells were present in the cover-slip preparations of the peritoneal exudate, and also large numbers of gram-negative bacilli. The turbid fluid which escaped from the peritoneal cavity at the time of operation, was collected in a sterile tube and sent immediately to the bacteriological laboratory. Broth tubes were inoculated with this fluid, and then incubated for twenty-four hours at 37° C; agar plates were also made direct from the fluid. The broth tube shewed a good growth in twenty-four hours. This was then plated on a series of agar plates. A culture of the staphylococcus aureus was obtained from all the plates. Numerous colonies of a gram-negative bacillus were also seen on each plate. Many of these colonies were tested with positive typhoid serum, but the bacilli present in each colony which was examined failed to give an agglutination reaction. This bacillus proved to be the bacillus coli.

Case 2.—Male, aged thirty. There were about two pints of milky fluid in the lower portion of the abdomen and also much free gas. Two minute perforations were found close to the ileo-caecal valve. Both perforations were invaginated by sutures, and the lower half of the peritoneal cavity was washed out with normal saline solution. The patient died forty-eight hours later.

Cover-slip preparations were made of the peritoneal exudate at the time of the operation. Large masses of polynuclear neutrophils were seen in the films, many of which were phagocytic. Gram-positive cocci and gram-negative bacilli were also seen. Aerobic and anaerobic cultures were made from the fluid in the peritoneal cavity. Three strains of the bacillus coli were isolated from this exudate, and two of these strains which were fully examined were found to differ, not only in their cultural characteristics but also in their pathogenicity to guinea-pigs. The importance of these facts concerning the colon bacillus cannot be overestimated, and we have, therefore, dealt fully with this subject in a later chapter. Large numbers of colonies of bacilli which grew on the agar plates were tested with positive typhoid serum but failed to give any reaction. A gram-positive staphylococcus was present in the film preparations of the peritoneal exudate and in the original cultures both aerobic and anaerobic, but we did not obtain any colonies of the coccus on any of the plates.

Lastly, although Flexner and Vincent have found streptococci frequently in the peritoneal cavity of cases dead from perforation of the intestine in typhoid fever, we have not observed this coccus in either of our cases examined at the time of operation.

Turning now to the clinical aspect of our two cases, we find that perforation occurred in the third and sixth week of illness, and that the operation was undertaken respectively forty-eight and ten hours after perforation. Both were treated by suture, limited lavage, and drainage, and both patients died. The bacillus typhosus was found in neither case ; in one the colon bacillus only was isolated, and in the other the colon bacillus and the staphylococcus aureus. In both, the post mortem examination showed intense universal peritonitis to be present. In these cases, owing to the limited exposure at the operation, we were unable to ascertain the bacteriological condition of the peritoneum in a remote region.

Harte and Ashurst collected from the literature records of 362 cases of intestinal perforation during enteric fever which were submitted to operation. The mortality was 74 per cent. More recent statistics from the Johns Hopkins Hospital place the mortality at a lower figure, whilst in Prof. Osler's own eleven cases it was still lower, being only 54·5 per cent. Now this death-rate is appreciably lower than that of perforative appendicitis, which, when we consider that in the one case the patient is debilitated by two or more weeks of an exhausting illness, whilst in the other, he is usually attacked when in perfect health, is sufficient to excite our curiosity. It is even most striking when we consider that operations undertaken for perforation occurring during a relapse, shew a lower rate of mortality than those which occur in an initial attack. It may be that one contributing factor is that the patient is already under skilled observation, so that a diagnosis can be made and operation proceeded with earlier. We venture to think that there are other explanations also. In the first place, the gradual thinning and distension of the intestine will have allowed time, in the typhoid cases, for the natural protective mechanism of the peritoneum to have been called into play; in the perforated appendix cases, on the other hand, the lethal organisms are suddenly, as it were, launched upon an unprepared peritoneum. Again, the patient is usually so ill, in the typhoid cases, when operated upon, that the surgeon not only operates with the utmost rapidity, a factor of no little importance in all acute abdominal operations, but dares not douch and scour the peritoneum with the same heroism as he sometimes applies to the appendix cases.

Perforation of a Malignant Growth of the Colon.

The following instance of perforation of a carcinoma of the colon illustrates well the rôle played by the staphylococcus albus in peritonitis, and is in complete harmony with the appendicitis cases. A woman, aged sixty, had had an abdominal tumour, accompanied by chronic constipation, for nine months. For five days the tumour had been more painful. When admitted the temperature was 102°, and on the previous day she had had a rigor. The abdomen was rather distended, but obstruction was not absolute. The abdomen was opened in the mid-line, when omentum of normal appearance presented. This proved to be sterile. Proceeding towards the tumour, the intestines in its neighbourhood were found to be reddened, but not distended; cultures from the gut surface gave a pure growth of the staphylococcus albus. Close to the tumour there was some clear fluid, which also gave a pure culture of the staphylococcus albus. Film preparations of this fluid contained large numbers of healthy polynuclear cells, but no micro-organisms. The peritoneal cavity was then packed off with strips of gauze, and a foul abscess was opened. Film preparations of the pus showed numerous degenerated cells, as well as gram-positive cocci and gram-negative bacilli. From the cultures were isolated the colon bacillus and the staphylococcus albus. We did not obtain a growth of anaerobic organisms, although every precaution was used. The patient died on the fourth day, and at the autopsy a condition of intense diffuse peritonitis was found. There is little doubt that the colon bacillus had invaded the general peritoneal cavity owing to the opening of the abscess, and given rise to the fatal peritonitis. We have here, however, a clear example of the protective influence afforded by the staphylococcus albus and its attendant phagocytic cells, which, owing to the slow progress of the disease, had been able to exert a restraining power on the colon bacillus, and prevented this organism from terminating the patient's life earlier.

CHAPTER VII

PERITONITIS DEPENDENT UPON APPENDICITIS

ALTHOUGH the usual clinical distinctions are found by bacteriological examination to be only approximately accurate, we have found it convenient to follow that classification for the purpose of enumerating the ninety-three cases which we have examined. They are, therefore, considered under the headings of Diffuse Peritonitis, Local Abscess, Secondary Complications, and Interval Cases.

The cases of acute appendicitis, other than those of local abscess, we have divided according to whether there was or was not a definite perforation present. In the one class are included some cases of gangrene, and some of deep ulceration where the peritoneal tissue alone formed the wall; in the other are all degrees from the minute perforation, found only on close examination, up to a complete disruption of the appendix. Our object has been to ascertain the bacteriological condition of the peritoneum as far away from the appendix as possible, as well as in its immediate neighbourhood. We have now to inquire how far the results harmonise with the clinical aspect of the cases.

Acute Non-perforative Appendicitis.

In three instances operation was undertaken before bacterial infection of the peritoneum had occurred. These were operated upon respectively twenty, twenty-seven, and forty-eight hours after the onset of the illness, and all of them presented very acute symptoms, the pulse rate being increased out of proportion to the height of the temperature. In only one case was any exudate seen, and this consisted of a small quantity of almost clear fluid which, microscopically, contained enormous numbers of polynuclear cells. In each case the intestines in the lower part of the abdomen were reddened and distended.

The appendices were remarkably unlike one another. One was a large, extremely thin sac, containing pus, with a few flakes of lymph on its surface; another was small, very oedematous, and of a bright red colour, with a small flake of lymph on its surface. The third was large, of uniform black colour, with a shiny peritoneal surface; there was no bleeding from the mesentery when cut across, and the appendix was rigid, so that there was evidently thrombosis throughout the organ. On section the walls were found to hold myriads of micro-organisms. (Fig. 4.)

Of these three cases one proved fatal from peritonitis, which was in all probability due to the fact that the distended small intestine was opened in order to empty it and to introduce magnesium sulphate into it. It may of course be said that the infection took place in removing the appendix, but we consider this not so probable, as the same method of removal, namely by means of the clamp without opening the lumen, was in each instance employed, and by the same operator. At the autopsy the stump was found secure. Moreover, evisceration and thorough irrigation were employed in the fatal case, whereas dry sponging was the method used in the other two. To this point attention will be directed later. In the other two cases, no drainage was employed, and the wounds healed by first intention.

In eight of the eleven non-perforative cases the peritoneum was found to be infected at the time of operation. In one instance the staphylococcus albus was the only organism present. The patient was a boy, seventeen years of age, with a history of four days' illness. The pulse was 88 and the temperature 102°. The staphylococcus albus was isolated from the surface of the acutely inflamed appendix; the peritoneal exudate contained polynuclear and endothelial cells, and the peritoneum at a distance was sterile. There were no adhesions. The appendix was large and swollen, and in places exhibited necrotic patches. It was removed, the peritoneum in the neighbourhood was carefully sponged, and the abdomen closed. Recovery was uneventful, except that the wound suppurated.

In three instances the colon bacillus was the only organism found. One of these recovered, but in this case unfortunately only the region of the appendix was examined bacteriologically, whilst the turbid, non-smelling fluid at a distance was not investigated. In this instance the illness had lasted only twenty-four hours, the peritoneum, after removal of the appendix, was treated by local dry sponging and drainage, and the patient recovered. The second case was of three days' history, in a boy aged thirteen. Two types of exudate were present; in a remote region it was turbid and odourless, shewed in film preparations large numbers of polynuclear cells, but no organisms, and was sterile; in the immediate neighbourhood of the appendix, but not in a localised abscess cavity, there was thick, offensive pus, which shewed in films only gram-negative bacilli, and on cultivation grew only the colon bacillus. The appendix was removed and the peritoneal cavity washed out and drained. Death took place on the tenth day, and at the autopsy there was found a condition of universal purulent peritonitis.

The third case was that of a child three years of age, with a history of ten days' illness. The pulse was 150 and the temperature 100°. At a distance from the appendix there was a quantity of turbid brownish fluid, which, in films, showed polynuclear cells and gram-negative bacilli, but no other organisms. In cultures only the colon bacillus was grown. Immediately round the appendix, which was gangrenous but not perforated, there was thick, foul pus, from which also the colon bacillus alone was obtained. The appendix was removed and the abdomen washed out and drained, but death occurred in a few hours.

In the remaining four cases of non-perforative appendicitis more than one organism was found.

1. Bacillus pyocyaneus and staphylococcus albus, both remotely and close to the appendix.
2. Bacillus coli, staphylococcus albus, and staphylococcus aureus in both regions.
3. Bacillus coli and a staphylococcus in both regions.
4. Staphylococcus albus alone at a distance, and bacillus coli together with staphylococcus albus close to the appendix.

The first three proved fatal, but the fourth recovered after a severe struggle.

The following is a brief summary of these four cases.

1. A girl, ten years of age, had been ill for three days, and on admission signs of diffuse peritonitis were present. The pulse was 120 and the temperature 103°. Thin offensive fluid was present in the upper part of the peritoneal cavity, and thick foul pus around the appendix. Films of the pus showed polynuclear cells, gram-negative bacilli, and gram-positive cocci. Cultures of both fluids yielded the bacillus pyocyaneus and the staphylococcus albus. The appendix was necrotic, but not perforated, and contained concretions. It was removed, and the peritoneum was sponged and drained. Death occurred on the third day. Post mortem there was a condition of universal purulent peritonitis.

2. A girl, aged twenty, had been ill for four days. The pulse was 150 and the temperature 102°. The appendix was gangrenous, but not perforated. The intestines were everywhere reddened but not greatly distended, and were bathed with a large amount of turbid offensive fluid. Films and cultures both at a distance and from the surface of the appendix showed polynuclear cells, gram-negative bacilli, and gram-positive cocci in groups. From the cultures were isolated the colon bacillus, the staphylococcus albus, and the staphylococcus aureus. The appendix was removed, the abdomen thoroughly washed out, and closed without drainage. Death occurred on the following day.

3. A girl aged sixteen had been ill for two days. The pulse was 124 and the temperature 102°. The appendix was acutely inflamed, but the intestines showed little evidence of peritonitis. There was a small amount of clear fluid exudate without smell. Films showed polynuclear cells, most degenerated, but no micro-organisms. Cultures, both remotely and from the surface of the appendix gave a growth of the colon bacillus and also of a staphylococcus which died out. The interior of the appendix, examined both aerobically and anaerobically, showed only the colon bacillus. The appendix was removed, the peritoneum sponged, and the abdomen closed. Death took place on the third day.

4. This case is of particular bacteriological and clinical interest. A woman aged thirty-five had had an appendix abscess opened eleven weeks previously, which had healed. She was admitted with a history of a few days' illness. There were signs of diffuse peritonitis, together with a pelvic swelling. On opening the abdomen the intestines were seen to be everywhere reddened, somewhat distended, and covered with a sticky exudate. This proved to be sterile.

Nearer to the pelvis was a small amount of thick, odourless fluid, not definitely shut off from the rest of the peritoneal cavity, which showed microscopically no cells and no organisms, but which yielded a pure culture of the staphylococcus albus. Close to the appendix was a very imperfectly localised collection of thick offensive pus. This pus, investigated both aerobically and anaerobically, showed the colon bacillus and the staphylococcus albus. The appendix, which was acutely inflamed but not perforated, was removed, and the peritoneum dry-sponged and drained. The patient recovered.

Perforative Appendicitis with Diffuse Peritonitis.

We have examined seventeen examples of this condition, the duration of the illness having varied from thirty-six hours to nine days. All were cases of what is usually called "general peritonitis," but the extent and degree of the peritoneal involvement varied considerably. In every case the changes were most intense in the right iliac fossa, and in those of longer history as a rule there had apparently been an abortive attempt at localisation, the thicker pus immediately round the appendix being feebly dammed back from the rest of the peritoneal cavity by agglutination of intestinal coils. In the worst cases of all there was no adhesion of any kind, and the perforated appendix lay quite free in the peritoneal cavity. The exudate varied greatly in quantity and quality. In some there was no difference between that immediately round the appendix and that in the remote upper part of the abdomen; in others, again, there was a very distinct difference between the foul pus round the appendix and the turbid odourless fluid in the upper part. It is this turbid exudate to which we attach great importance from the point of view of prognosis; it is similar to that produced by experimental inoculation of the staphylococcus albus into the peritoneal cavity of guinea-pigs; it contains innumerable phagocytes.

In every case but one the colon bacillus was found free in the peritoneal cavity in the neighbourhood of the appendix, the one exception having the bacillus pyocyaneus and no colon bacillus. The peritoneum at a distance was investigated fifteen times; on one occasion the odourless fluid around the spleen was sterile both in films and cultures, whilst the films showed many polynuclear cells; in one case the staphylococcus cereus albus was alone present; in one the streptococcus pyogenes; and in one the staphylococcus albus and the colon bacillus. The colon bacillus was found alone on nine occasions. The relation of cover-slip examinations to culture methods, upon which so much stress is laid by those who regard the colon bacillus as of secondary importance, has been discussed elsewhere; but it is worth while in this place drawing attention to a striking point brought out by this series, namely, that on the one occasion in which streptococci were seen in the films, they were also recovered culturally.

There does not appear to be any constant relation between the length of history of the illness and the bacteriological results. The colon bacillus may be found in a remote upper part of the peritoneum in less than forty-eight hours from the onset, and, on the other hand, such a region may be sterile after five days' illness.

In discussing the result of treatment we consider together all the cases of diffuse peritonitis, both perforative and non-perforative, and these make up a total of twenty-eight. In fourteen of these cases the colon bacillus was present in the exudate at a distance from the caecal region; only three recovered. Two, in which the colon bacillus was found alone, were treated by appendicectomy, local dry sponging of the peritoneum, and drainage ; the third had the staphylococcus albus present as well as the colon bacillus, and was treated by removal of the appendix, general peritoneal lavage (but without evisceration), and drainage. This last case was one in which there had been a definite swelling present for nine days, and where the symptoms of diffuse peritonitis, coincident with the disappearance of the swelling, had been present only a few hours before operation. Of the eleven fatal cases, not one was treated by dry sponging, but all by copious peritoneal lavage, assisted, in the majority, by evisceration. These fourteen cases, then, show a mortality of nearly 80 per cent. Now how do these results compare with the general run of cases of which we do not know the bacteriology ? During the five years, from 1899 to 1903, there were operated upon at St. Thomas's Hospital 119 cases of appendicitis with diffuse peritonitis. One hundred were treated by washing the peritoneum with large quantities of sterile water or normal saline solution, and of these eighty died. The remaining nineteen were treated locally, although the peritonitis was diffuse, that is to say, only the intestines in the neighbourhood of the caecum were either sponged or washed over, whilst the upper part of the peritoneal cavity was not interfered with, and of these ten died. The mortality, then, for general lavage is eighty, and for local lavage or dry sponging only 47 per cent. It may be pointed out that perhaps only the less severe cases were treated by local cleansing, but our reply is that we now know it to be *impossible* from examination at the operation to estimate the extent of the peritonitis, still less the nature and virulence of the infecting organism, so that selection of that kind is impracticable. On the contrary, the cases which our bacteriological examinations have taught us to be the less fatal, are often the very ones which appear, from the amount of the exudate, to be the most severe, and which would, therefore, probably receive the more energetic form of treatment.

The cases which have been operated upon by one of us acting, at various times, for the surgeons at St. Thomas's Hospital, illustrate our point in a somewhat striking manner. Out of a total of twenty-five cases, nineteen were treated by evisceration and thorough washing of the peritoneal cavity, the upper part being dealt with as thoroughly as the lower, and of these eighteen died. The remaining six were treated locally, leaving the upper region of the peritoneal cavity undisturbed, and every one recovered, These cases were in no way selected, as, with one exception, they are the last cases in the series. One patient in fact was marked out for this line of treatment by the severity of his general condition, because he was much too ill to stand extensive manipulation. This was the case of a boy, aged nineteen, who had been ill for four days. The appendix was gangrenous and perforated ; the intestines were everywhere inflamed and distended and bathed with turbid fluid, which, odourless in the greater part, was of the usual smell in the region of the appendix, although not shut off by adhesions. The appendix was removed, and the caecal region dry sponged and drained. The patient was extremely ill for two or three days, but ultimately made a complete recovery.

An almost exactly similar case, treated differently, had a different result. A patient of the same age as the last had been ill for five days. The appendix was perforated, and the intestines were everywhere red and distended. A large quantity of turbid odourless fluid was free in the peritoneal cavity, even round the spleen. This exudate after removal of the appendix was thoroughly washed away with large quantities of saline solution. Death took place on the fourth day, and at the autopsy a condition of universal peritonitis was found. Now the exudate was in this instance examined in two situations both by films and cultures. About the spleen it shewed polynuclear and mononuclear cells, but no organisms, and remained sterile on cultivation. Close to the appendix the exudate shewed polynuclear cells and gram-negative bacilli only, and grew both aerobically and anaero-bically the colon bacillus only. There can be little doubt that in this instance the interference with the sterile upper region of the abdomen not only spread the infection over a previously unaffected part, but also washed away the phagocytic cells upon which in our opinion the chief possibility of recovery probably depends.

The single instance, in this series of twenty-five, of recovery after general lavage occurred in a previously healthy man of twenty-two, who had been ill for thirty-six hours, and on admission presented the signs of diffuse peritonitis, with a temperature of 100·6° and a pulse of 100. The appendix was acutely inflamed, and showed a minute perforation. There was a little clear exudate around it, and the intestines in the immediate neighbourhood were reddened and distended, but although the peritonitis was diffuse, it, as yet, involved only a small area of the peritoneum. The appendix was removed, the abdomen thoroughly washed out, and closed without drainage. The peritoneum in the upper region proved to be sterile, whilst the exudate around the appendix contained the staphylococcus albus and the colon bacillus. The wound suppurated ten days later. The pus from this abscess contained the colon bacillus and a staphylococcus which was not identified.

Appendicitis with Definitely Localised Abscess.

The bacteriology of the pus from a localised abscess is of little clinical interest, being practically the bacteriology of the intestinal contents. The very fact that it has become localised is evidence of a sufficient degree of resistance on the part of the patient. The peculiarly disgusting smell of the pus cannot be said to be characteristic of any particular organism. Veillon and Zuber consider it to be due to the various anaerobic organisms which they have isolated, and Tavel and Lanz attribute it to what they term the pseudotetanus bacillus. Four of our abscess cases, or ten per cent., failed to shew any evidence of the colon bacillus, whilst the bacillus pyocyaneus was isolated from three of these four cases.

The condition of the peritoneum beyond the abscess, however, is of considerable interest. In most of our cases, the abscess being adherent to the abdominal wall, it was impossible to examine the peritoneum beyond, but in sixteen instances the pus had to be reached through the general peritoneal cavity, and these we examined bacteriologically. Nine proved sterile, whilst no less than seven grew a pure culture of the staphylococcus albus. In most cases there was an appreciable quantity of clear odourless fluid in the peritoneal cavity, and as a rule the intestines and omentum in the immediate neighbourhood of the abscess were reddened and a little distended.

Of the total number of forty cases of local abscess, only two died, but neither of them from diffuse peritonitis.

One was a girl seven years of age, who had been ill for five days, and was admitted with a pulse of 120 and temperature of 102°. It was doubtful whether the peritonitis was localised, and accordingly an exploratory incision was made through the left rectus. The culture taken from this situation subsequently proved to be sterile. A localised abscess was then opened through the right rectus. The child died within a few hours, and autopsy showed a large pulmonary infarct and septicaemic changes in the viscera, but no signs of diffuse peritonitis. The other case was that of a boy, eighteen years of age, who had been ill for thirteen days with abdominal symptoms, and irregular fever including a succession of rigors. Here again the peritonitis was not diffuse, and death occurred within a few hours after operation.

It appears that the opening of an abscess which is not adherent to the abdominal wall, provided that the peritoneal cavity is efficiently packed off with gauze, which is left *in situ* for two or three days after operation, is attended with little, if any, additional risk.

We were fortunate to observe two cases of appendix abscess which had to be reached through the peritoneal cavity, operated upon on the same day by the same surgeon, and under precisely similar circumstances, a comparison of which offers significant support to our contention regarding the staphylococcus albus. One was a man, thirty-four years of age, who had had two previous attacks of appendicitis, and had on this occasion been ill for fourteen days. When admitted the temperature was 103° and the pulse 100. The other was a boy of thirteen, in his first attack, who had been ill for five days. His temperature was 103° and his pulse 112. In both cases the abscess was situated to the outer side of the caecum. The general peritoneal cavity was first opened, and in each instance contained a small quantity of clear odourless fluid, from which cultures were made. The peritoneal cavity was not packed off in either case, but the abscess was opened and a drainage tube inserted. From the foul pus the same organisms were obtained in both cases, but the man's peritoneal exudate gave a pure culture of the staphylococcus albus, whilst the boy's was sterile. The subsequent progress was very different in the two cases. On the following morning the man was remarkably well; his temperature was 100·8°, his pulse 88, the abdomen was soft and moving well, and there was neither sickness nor intestinal distension. Recovery was rapid and uninterrupted. The boy on the other hand presented a strikingly different picture. He looked seriously ill, with anxious facial expression, sunken eyes, and vomiting. The pulse was 142 and the temperature 100·8°. The abdomen was rigid, moved badly, and was distended. Aperients and enemeta were given with good result, and on the morning of the third day the condition had begun to improve. The subsequent progress was good, and recovery ensued.

There is a class of cases intermediate between the local abscesses on the one hand and the most acute perforative cases on the other, calling for special attention because of the difficulty to which they give rise regarding the advisability of immediate operation. Opinion has gradually come round to the view that operation should be done upon nearly every case of appendicitis as soon as the diagnosis has been made, but the period about which alone any serious discussion still lingers, is the period which lies between the second or third and fifth or sixth days. These are the cases in which nature is carrying on a hard fight against the invading organisms, and the event hovers in the balance between the formation of a local abscess, when the natural protective forces may be said to have triumphed, and the diffusion of the peritonitis which will, if left alone, lead inevitably to a fatal issue. The question whether at this stage nature can be assisted by surgery is one of the most difficult which the surgeon is called upon to answer. We, therefore, turn to bacteriology to see whether any light is shed by it upon the question.

PERITONITIS DEPENDENT UPON APPENDICITIS

There are six cases in our series which may fairly be said to come under this heading, and may be set out thus :—

No.	Sex.	Age.	Day of illness.	Exudate at a distance.	Exudate round appendix.	Treatment.	Result.
1	F.	21	Sixth	Sterile	B. Coli	General lavage	Died
2	M.	18	Seventh	Staphylococcus cereus albus	B. Coli	ditto.	Died
3	M.	19	Fourth	B. Coli	B. Coli	ditto.	Died
4	M.	20	Fourth	B. Coli	B. Coli	ditto.	Died
5	F.	19	Third	B. Coli	B. Coli	Local dry sponging	Recovered
6	F.	15	Fifth	Staphylococcus albus	B. Coli & Staphylococcus albus	ditto.	Recovered

The conditions common to these six cases were that the colon bacillus was present immediately around the appendix in foul smelling pus, which was feebly shut off from the inflamed peritoneum around by the agglutination of neighbouring coils of intestine or of omentum ; and that, clinically, it was doubtful before, and even at the time of operation, whether the condition was one of diffuse peritonitis or not. In three cases the colon bacillus was already present upon the peritoneum at a distance from the agglutinated area ; one was sterile, and the other two had staphylococci only.

What would have happened if no operation had been performed it is impossible to say, but it seems probable that the first three would have succumbed to the peritonitis which was already diffuse but not universal, whilst the other three *might* have formed a local abscess. The most important point, however, which is brought out in this table is, that the four cases which proved fatal from universal peritonitis were all subjected to thorough washing out of the peritoneal cavity, whilst the two which recovered, although one contained the colon bacillus beyond the limits of the feebly shut off pus, were treated by local dry sponging and drainage.

We conclude, therefore, that in these doubtful cases which present themselves for treatment after the second day of illness and before the formation of a definitely localised abscess, whilst it is impossible to say what the outcome will be if left alone, yet operation may be performed without grave risk provided that every effort is made to limit the area of operation, and to avoid the diffusion of septic material by too energetic treatment.

Secondary Complications.

We now come to cases of infection at a distance from, but dependent upon, appendicitis, and we are able to compare the organisms found in these complications with those of the original disease. We have had the opportunity of examining—

Two cases of subphrenic abscess,
Four other residual intraperitoneal abscesses,
One empyema,
One abscess of the abdominal wall,
One acute pleuritis, and
One suppurative parotitis.

These cases throw an important light upon the bacteriology of peritonitis originating in disease of the appendix, and fall into harmony with our other observations, so that each deserves a brief notice.

Two cases of subphrenic abscess.—1. A female, nineteen years of age, had been operated upon three weeks previously for an imperfectly localised appendix abscess with diffuse peritonitis. A large quantity of turbid odourless fluid had been found in the peritoneal cavity, and the intestines generally were red and distended. The patient was extremely ill at the time, and nothing more than simple drainage was done. The turbid fluid proved to be sterile. The pus showed polynuclear cells and no micro-organisms in the films, and gave on cultivation only the staphylococcus albus. The temperature kept high, the general condition was one of severe septic poisoning, and at the end of three weeks signs of pressure were noted at the base of the left lung. A large foetid gas-containing abscess around the spleen was opened and drained. The patient recovered, and ten months later the appendix was removed, when practically no adhesions were encountered, and the staphylococcus albus was isolated from the surface of the appendix. Film preparations of the pus from the subphrenic abscess showed polynuclear cells, groups of gram-positive cocci, and gram-negative bacilli, whilst the colon bacillus and the staphylococcus cereus albus were cultivated from it.

2. The second subphrenic abscess occurred on the right side. The patient was a boy, fifteen years of age, who had had a localised, gas-containing abscess, from which a concretion escaped, opened fourteen days previously. This had been shown to contain the colon bacillus and the staphylococcus albus. The temperature remained high, and on the fifteenth day a small subphrenic abscess was opened. The pus contained the colon bacillus, the staphylococcus albus, and the bacillus proteus vulgaris. Two days later the patient died. At the autopsy similar purulent collections were found around the spleen and in the pelvis, and the bases of the lungs were necrotic.

Other Residual Abscesses.

Of the other intraperitoneal residual abscesses two were close to the caecum. The first occurred in a man, aged twenty-two, who had had an abscess drained and the appendix removed two years previously, and had been perfectly well in the interval. Films of the pus showed polynuclear cells, gram-positive cocci, and gram-negative bacilli. In both aerobic and anaerobic cultures the colon bacillus and the staphylococcus aureus were isolated. The patient recovered.

The second was that of a boy, twelve years of age, who had had the appendix removed and the abdomen thoroughly washed out for diffuse peritonitis two years previously, and who had been quite well in the interval. The pus from the residual abscess was thick and malodorous. Microscopically it showed gram-positive cocci, gram-negative bacilli, and polynuclear cells, which were mostly degenerated. Both aerobic and anaerobic cultures remained sterile. The patient recovered.

Two other residual abscesses, one subhepatic and one on the left side of the abdomen, occurred respectively seventeen and thirty days after the drainage of a local appendix abscess. Both contained thick odourless pus, which showed polynuclear cells in the films.

One, in which the pus was of a greenish colour, also showed a variety of bacilli and cocci, but on cultivation grew only the staphylococcus albus. The other showed exceedingly few bacilli, and these intracellular, and was sterile on cultivation.

A case of perforative appendicitis, in which the abdomen had been washed out and closed without drainage, developed an abscess in the abdominal wall ten days after the operation. The pus contained the colon bacillus and a staphyloccocus, both of which organisms had been isolated from the peritoneum.

A right-sided empyema, which proved fatal in a short time, occurred in a man of seventy. The pus showed gram-positive cocci as well as gram-negative bacilli, but on cultivation grew only the colon bacillus. Post mortem, the appendix was gangrenous, and there was a large subphrenic abscess, but no visible aperture in the diaphragm.

A patient who had had an appendix abscess opened three weeks previously showed signs of pressure on the base of the right lung. Exploration for suspected subphrenic abscess was undertaken, but no pus was found. Cultures from both pleura and peritoneum gave a pure growth of the staphylococcus albus.

A case of left-sided parotitis occurred in a boy aged fourteen, twenty-four hours after the opening of an appendix abscess of ten days' duration. The swelling gradually increased and softened, and was incised on the fourth day. Soft necrotic tissue, in very small amount, was found deeply in the gland. Films and cultures were taken. The former showed only cocci, arranged in groups, and the latter gave a pure growth of the staphylococcus aureus. The right parotid gland was not affected. The patient recovered. Unfortunately, we have no bacteriological examination of the pus in the appendix abscess. The patient's serum gave no agglutination reaction with the staphylococcus which was isolated.

Cases of appendicitis operated upon during a quiet period.

Sixteen such cases were examined; the peritoneum at distance in thirteen, the surface of the appendix in ten, and the interior of the appendix in nine. The peritoneum at a distance was sterile in ten, and showed the staphylococcus albus in three. The surface of the appendix was sterile twice, and showed " staphylococci " eight times. The interior showed the colon bacillus alone seven times, and "staphylococci" alone twice.

The peritoneum at a distance was sterile in four out of six cases where the previous attack had been of the "catarrhal" variety; twice only was "a staphylococcus" found. The operations were performed from one to eight weeks after the attack had subsided.

Of the cases where the previous attack had culminated in an abscess, and where the patients had returned for appendicectomy with the wounds healed, a much larger proportion, namely *eight out of ten*, grew "staphylococci." The percentage of sterile cases after abscess formation is only twenty, whereas after a catarrhal attack it is sixty-six. The operations were undertaken from two to eight months after the abscess had been opened.

In the whole series of sixteen cases, suppuration of the abdominal wound occurred only four times, and one of these was the case in which the staphylococcus aureus was present on the surface of the appendix. All the patients recovered.

In one instance, after an interval of four months, a small collection of thick white odourless pus was found near the base of the appendix, amongst some adhesions. From this a pure growth of the staphylococcus albus was obtained.

CHAPTER VIII

THE BACTERIOLOGY OF APPENDICITIS

THIS subject has been investigated by numerous observers, but the most important communications are those by Tavel and Lanz, in 1893 and 1904. The valuable contribution to the bacteriology of this subject which these observers made in 1893 has formed the basis on which most of the work of the present day rests. It is most unfortunate, however, that so much time has been given to the bacteriology of appendix abscesses, as it was hardly probable that the actual cause of appendicitis would be found by examining the contents of an offensive abscess cavity.

There is no doubt that the chief interest in this subject centres round the colon bacillus. At one time it was thought that this was the most important organism in the aetiology of peritonitis, whether due to appendicitis or otherwise. Other observers adopted an entirely different view, namely, that the colon bacillus is an organism which is very easy to cultivate and grows very rapidly and, therefore, the more delicate but more virulent organisms are never isolated. This idea has become widely popular, and is the view which is generally accepted at the present day. In 1898, Veillon and Zuber announced that they had sufficient evidence to show that certain anaerobic organisms play the most important part in the bacteriology of appendicitis. Tavel and Lanz, in their latest communication, also give support to the views of Veillon and Zuber. Hewetson, however, has recently published a preliminary paper on the bacteriology of peritonitis, and, like ourselves, has failed to find any evidence to show that anaerobic organisms are of any importance in appendicitis.

It has already been stated that many observers hold that the colon bacillus outgrows the more delicate micro-organisms which are most concerned in the bacteriology of appendicitis. It is the streptococcus pyogenes, the pneumococcus and "staphylococci" which are supposed to be most easily outgrown by the bacillus coli.

The Relation of the Streptococcus Pyogenes to Appendicitis.

Those who have devoted time to the study of this subject must have met with cases which were due to this coccus, but no one has been able to do more than suggest that the streptococcus pyogenes is a common organism in this disease. It is true that some of the older writers considered that almost every case of peritonitis was due to the streptococcus pyogenes, but a complete bacteriological investigation was seldom made, and it is extremely doubtful if there was sufficient evidence to support this idea. It is impossible to be certain of the nature of some of the micro-organisms which have been described in recorded cases of appendicitis, as "streptococci," because this does not by any means imply that the organism in question was the streptococcus pyogenes. In all our cases, we have made every effort to prove the nature of the organism which we were investigating. Cover-slip preparations and aerobic and anaerobic cultures of the peritoneal exudate were made in the large proportion of cases. In every instance in which we found chains of cocci in film preparations of the pus or peritoneal fluid, we also grew the organism on artificial media.

It can, therefore, be said, that if there was no evidence of the streptococcus by any of the methods which we employed, it was extremely unlikely that the organism was present.

E. M. Corner appears to be of the same opinion as Harvey Cushing, and many others who hold that the "streptococcus" is usually lost in artificial cultures, because, he says, "although it (the streptococcus) is one of the most widely distributed of organisms, it is very easily killed and lost in mixed cultures, and may literally vanish before a member of the colon group." It is hardly probable, however, that we should have failed to find a streptococcus either in the film preparations of the pus, or in the various cultures employed in each case. Experience does not teach us that the streptococcus pyogenes dies out, or any way cannot be isolated, in the presence of the colon bacillus. It is true that in some cases of appendix abscess cocci have been present in cover-slip preparations of the pus, whilst the organisms have not been cultivated. We do not attach any importance to this fact, as the pus in these abscesses may contain numerous micro-organisms which are never cultivated; in fact, the pus in these abscesses sometimes appear to contain enormous numbers of micro-organisms of every shape and size, because we are merely examining the contents of the intestine. If, however, diffuse peritonitis supervenes on a case of appendix abscess, there is never any difficulty in isolating the micro-organisms which are in the peritoneal cavity, provided, of course, that the bowel contents are not free in the general cavity. If this occurs, we have a condition exactly similar to that found in an appendix abscess.

There is not a single instance among our cases in which the streptococcus pyogenes was obtained from the peritoneal cavity in acute diffuse non-perforative peritonitis due to appendicitis. If the streptococcus pyogenes is the important organism in appendicitis which Cushing, Corner, and others would lead us to believe, then we ought to have found it in some of the instances of this variety of peritonitis, which we have not been able to do. Here is the direct proof which has long been wanted, and it shows that the streptococcus pyogenes is seldom present in the peritoneal exudate in appendicitis. In conclusion, we should like to point out as still further proof, that in those cases of peritonitis in which the streptococcus pyogenes is found in the peritoneal cavity, the prognosis is practically hopeless. If therefore this organism were frequently present in the peritoneal exudate in appendicitis, the mortality would be very much higher than it is at present.

The Pneumococcus.

Barbacci, Krogius, and others have stated that they considered the pneumococcus to be an important organism in the bacteriology of "perityphlitis," whilst J. H. Bryant has offered the suggestion that the pneumococcus might possibly be found to be a very important organism in this disease, if only a more careful search were made. Dr. J. Eyre has recently found the pneumococcus in the interior of the appendix from a case of acute appendicitis. Veillon and Zuber, and others, have obtained a pure culture of the pneumococcus from the peritoneal exudate in cases of appendicitis. In one of our instances of appendix abscess, we isolated the pneumococcus with the colon bacillus. This is the only case in which we cultivated the pneumococcus either from the pus in the appendix abscess or in the peritoneal exudate in peritonitis associated with appendicitis. There is little doubt, that if the pneumococcus was the important organism in appendicitis which it has incorrectly been assumed to be, we should have obtained pure cultures of the organism from the peritoneal exudate in some of our cases quite apart from the presence of the coccus in a localised abscess. The usual tendency of the pneumococcus is to produce diffuse peritonitis without any of the changes which are met with in perforative peritonitis. In the case of appendicitis described by Veillon and Zuber, there was a large quantity of greenish-white, thick, non-offensive pus in the peritoneal cavity. We have not seen a single example of appendicitis of this nature.

The Pathogenic Staphylococci.

Tavel and Lanz were the first to demonstrate clearly that the pathogenic cocci might be the cause of "perityphlitis." It is, however, to E. M. Corner that the credit is due of first pointing out their great importance in this disease. In appendicitis, he says, "it seems not improbable that the origin of the acute cases of appendicitis lies with the septic organisms, which injure the tissues and so give the colon bacillus its opportunity." We read throughout the literature of appendicitis, and also peritonitis from other causes, the expression "staphylococci" used in the very widest sense. It should not be necessary to have to mention that it is impossible to obtain any information from such a statement as "staphylococci were present," beyond the actual definition of the word—staphylococci. If all staphylococci were of the same pathogenicity, perhaps such a loose terminology might be of little moment, but this is not so. The pathogenic properties of the staphylococcus pyogenes aureus are infinitely greater than any of the other staphylococci, and even the white staphylococci show all grades of pathogenic virulence. It is unnecessary to produce any further proof to show how incorrect it is to describe various micro-organisms in this manner.

We quite agree with Mr. Corner that the "staphylococci" play the most important part in the bacteriology of appendicitis. It has already been shown that the white staphylococci are the most important organisms in many other varieties of peritonitis, and we have evidence to show that the same is true of appendicitis. The staphylococcus pyogenes aureus appears to be an organism of much virulence in peritonitis and thus in direct contrast to the white staphylococcus. There is, however, a still further point to remember, that all cultures of the staphyloccus pyogenes aureus do not react in the same manner, as some are very much more virulent than others.

It will also be found that a typical culture of the staphylococcus pyogenes aureus may lose all its chromogenic properties when it is subcultured for the first time, and Dr. Dowson, and others, have observed the opposite effect. We have found that the chromogenic properties of this organism and the degree of pathogenesis increase in about the same ratio. There is one fact which appears to be quite certain, that there are many varieties of staphylococci intermediate between the white and the golden coccus.

The results of our experiments with the various white staphylococci obtained from the peritoneal exudate in cases of appendicitis are described elsewhere. Although various strains of this coccus were frequently injected into the peritoneal cavity of numerous guinea-pigs, we failed to produce suppurative peritonitis in a single instance, and this is exactly what is found to occur in the human peritoneum. It is for this reason that when the white staphylococcus has been isolated from the peritoneal exudate in peritonitis it has usually been considered to be due to "contamination," or that the coccus at least has had an epithelial origin, and has had nothing whatever to do with the bacteriology of peritonitis. We, however, have good reason to believe that this view is incorrect. We have found the white staphylococcus in almost every variety of peritonitis ; it is by far the most common organism met with in the peritoneal exudate " at a distance " from the site of origin of the acute lesion, and is frequently found in the peritoneal cavity in the " interval " cases of appendicitis. The important bearing which it is found to have on the prognosis of a case of peritonitis, when present in the peritoneal exudate alone or some time previous to the arrival of the colon bacillus, cannot be over-estimated. It does not appear to have any influence in the prognosis of those cases which are due to the streptococcus pyogenes, or the bacillus pyocyaneus.

We have obtained exactly similar results experimentally. If we injected the white staphylococcus into the peritoneal cavity of a guinea-pig, together with colon bacillus, the coccus was usually found to have little effect in preserving the life of the animal. If, however, we injected the coccus into the peritoneum some twenty hours previous to the colon bacillus, most striking results were obtained. The guinea-pig which had been inoculated in this way either recovered or lived for several days, finally dying from some cause outside the peritoneal cavity, whilst control animals, inoculated with the same strain of the colon bacillus, the same dose, and in the same manner, died within twenty-four hours. It is impossible to lay too much stress on these important observations, which not only show that this coccus is of the utmost significance in peritonitis, but that it has an entirely opposite effect to that which was expected ; in fact, we have another illustration of the great service which micro-organisms may render to man and animals.

We next proceeded to ascertain the action of this white coccus in cases of peritonitis. We used the guinea-pig for this purpose, as we have used it for all our other experiments. We injected definite quantities of a culture of the staphylococcus albus obtained from the peritoneal exudate in a case of appendicitis, into the peritoneal cavities of guinea-pigs, and examined the exudates at regular intervals of fifteen minutes, one hour, two hours, and twenty-four hours respectively. The results are fully described in another chapter, but it is sufficient to state here that this coccus caused a very large number of leucocytes to appear in the peritoneal cavity of these animals; but whilst the injections of the colon bacillus carried out in an exactly similar manner also produced similar results, the phagocytes were degenerated within one hour from the time of inoculation in the latter case, but appeared to be perfectly healthy at the end of twenty-four hours after injecting the white staphyloccocus. There was also much more peritoneal exudate after injecting the coccus than the bacillus. From these data, it will be seen that the chief results which arise from injecting the white coccus into the peritoneal cavity of animals are the production of an extensive phagocytosis and also, although we made no attempt to prove this, a selective action of the body fluids. If the colon bacillus and the staphylococcus albus are injected into the peritoneal cavity of an animal at one and the same time, it is found that the phagocytes are degenerated just as if the bacillus was injected alone.

The staphylococcus albus when present in the peritoneal cavity in peritonitis has, therefore, a definite function to perform and is not a "mere skin contamination," as some would have us believe. The fact, that the patient's serum has a marked agglutinative action towards this coccus isolated from the peritoneal cavity in some of these cases of appendicitis, is still further proof that the white staphylococcus bears an important relation to peritonitis.

Professor Welch delivered an address before the Congress of American Physicians and Surgeons, in 1892, entitled "Conditions underlying the Infection of Wounds." It was in this address that Professor Welch first drew attention to a white staphylococcus—the staphylococcus epidermidis albus. He directed our attention to the work of Bumm, Garré, Waterhouse, and others, who have shown that "large numbers of the pyogenic cocci can be injected into human tissues without effect." These observations are of very great importance in the light of recent work. We have shown similar results from our experiments, but with some important distinctions. It is true that there was "no effect" to the naked eye unless a very careful examination was made of the tissues of the inoculated animal or human being, but if such an examination is made, we find that a very decided effect has been produced. Professor Welch clearly shows in this lecture that the white staphylococcus plays a very important part in the healing of an aseptic wound, and still further, he refers to a case of peritonitis in which this coccus was found to play an important part. In a fatal case of "hystero-myomectomy," a volvulus of the ileum was found at the autopsy. There was a fibrino-purulent peritonitis present corresponding to the peritoneum covering the ileum, and a pure culture of the white coccus was obtained from the inflamed peritoneum. In concluding this excellent paper, Professor Welch expressed the opinion that the white staphylococcus which is found so frequently in aseptic wounds, in stitch abscesses, and in the skin, is an attenuated variety of the staphylococcus albus. We have given our views as to whether we consider that the white coccus which we have found with such regularity in peritonitis is the same organism as the staphylococcus epidermidis albus of Welch. We should mention here, however, that a stitch abscess is very seldom seen in the wards of St. Thomas's Hospital, although the white coccus has been so frequently isolated from the peritoneal cavity in peritonitis.

Anaerobic Micro-organisms and their Relation to Appendicitis.

Veillon and Zuber published a paper in 1898, on the bacteriological findings of twenty-two cases of appendicitis. They drew attention to the importance of certain anaerobic organisms which they considered to be the most important organisms concerned in the bacteriology of appendicitis. They described altogether six micro-organisms, namely, the bacillus fragilis, bacillus ramosus, bacillus perfringens, bacillus fusiformis, bacillus furcosus, and the staphylococcus parvulus. All these organisms were found to be strict anaerobes, pathogenic to animals, and were constantly present in the pus of appendix abscesses, and in the general peritoneal cavity in cases of peritonitis. These observers consider that gangrene of the appendix, and the offensive odour of the pus in appendix abscesses, are due to these organisms, and that their toxins give rise to the toxaemia which is the cause of death in appendicitis. This important communication produced a considerable amount of discussion, and many considered that much of the previous work on appendicitis was, in the light of these investigations, valueless. Tavel and Lanz, in their latest communication on the bacteriology of appendicitis appear to have come to a somewhat similar conclusion. They place considerable importance on the presence of the "bacillus

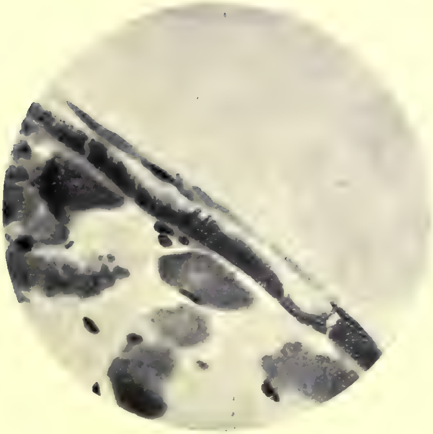

FIG. 5.—Section of guinea-pig's diaphragm, showing enormous masses of colon bacilli, just beneath the intact endothelium. Animal died within twenty-four hours, after receiving an intra-peritoneal injection of the colon bacillus.
[*No.* " *B* " *eyepiece :* " *D.D.*" *obj.*]

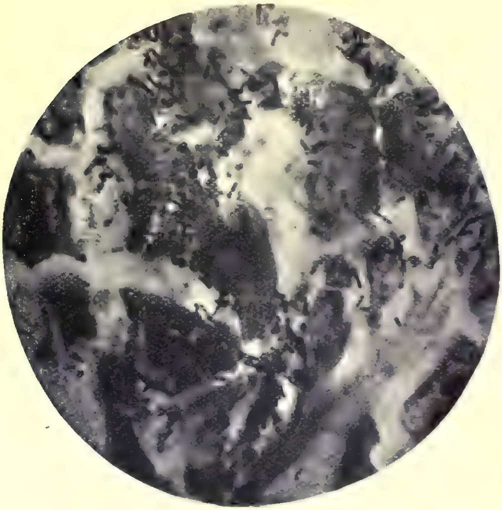

FIG. 6.—" Foaming liver " of rabbit, showing enormous masses of the bacillus aërogenes capsulatus, and the liver cells widely separated. Rabbit was inoculated according to the method of Professor Welch. Section was stained with Professor Leishman's stain.
[*No.* " *B* " *eyepiece ;* $\frac{1}{12}$ *oil-immersion.*]

pseudo-tetanus" which is the same organism as the bacillus fragilis of Veillon and Zuber, and also to a class of anaerobic bacilli which they describe as the bacilli of malignant oedema. We can state at the outset that we entirely disagree with the results of the investigations to which we have just referred. We employed strict anaerobic precautions in a very large percentage of the cases of appendicitis which we examined, and also in other varieties of peritonitis, but failed to find these anaerobic organisms, except in one instance. This was an example of appendix abscess in which the appendix was found to be gangrenous. The bacillus coli, a streptococcus, and the bacillus aerogenes capsulatus of Welch were present in the abscess. This anaerobic bacillus was obtained in pure culture from the surface of agar plates incubated under strict anaerobic precautions in a Bulloch's jar. The bacillus produced extensive bloody emphysematous oedema when inoculated into the subcutaneous tissues of a guinea-pig, and the emphysematous oedema spread very rapidly through the entire subcutaneous tissues of the animal, and produced death in twenty-four hours. The organism was present in pure culture in the subcutaneous tissues of the animal. When it was injected into the vein of a rabbit and the animal was killed two minutes later, and then placed in the incubator at 22° C. for twenty-four hours, certain changes were found which are specifically characteristic of this bacillus. The rabbit was found to be about twice the original size, the eyes were protruding from its head, there was general subcutaneous emphysema, foaming viscera (Fig. 6), free gas in the blood, and emboli of bacilli throughout the various internal organs. Professor Welch considers that the organism is capsulated, but we have always failed to demonstrate a capsule to the bacilli obtained direct from the tissues. This bacillus is described by Veillon and Zuber as the bacillus perfringens, and is classed as one of the bacilli of malignant oedema by Tavel and Lanz. It is most unfortunate that these investigators should have adopted this classification, as Professor Welch has proved beyond question that the important organism in so-called malignant oedema or emphysematous gangrene is the bacillus aerogenes capsulatus—an entirely different bacillus to the bacillus of malignant oedema, which was considered on the Continent to be the cause of emphysematous gangrene until Professor Welch published his important communication. We have dealt with this point more fully in a paper recently brought before the Pathological Society of London, on Emphysematous Gangrene of the Extremities.

The case from which we isolated Welch's bacillus made an excellent recovery. The weakest point in the paper by Veillon and Zuber, which appears to have escaped attention, is that if an organism such as the bacillus aerogenes capsulatus was frequently present in the peritoneal cavity in cases of appendicitis, as they have stated, emphysematous gangrene of the bowel should be a common lesion, instead of an interesting curiosity in pathology; the same condition should be found to occur in the abdominal wall, which is not so; and foaming viscera should be frequently seen at the autopsies on cases of appendicitis, instead of which there have been only two instances of this condition in the post mortem records of St. Thomas's Hospital for 1904. These few points and our own investigations on the bacteriology of appendicitis are sufficient to show that the work of Veillon and Zuber is only of interest owing to the exceptional results which they obtained. Hewetson, in the communication to which we have already referred, has also failed to confirm the work of Veillon and Zuber.

THE BACTERIOLOGY OF APPENDICITIS

In almost every case of appendicitis large numbers of cocci, bacilli and spirilla are present in the film preparations of the appendix abscess, which are not cultivated; the contents of these abscesses is simply in a great many instances the intestinal flora.

Bacillus Pyocyaneus.

It was originally considered by Koch that this bacillus was non-pathogenic. We now know that it may be extremely pathogenic to man, and is often one of the most virulent of all known micro-organisms to the small laboratory animals. Cultures of this bacillus do, however, vary considerably in their pathogenic properties. The only question which we wish to discuss here is the relation of this organism to peritonitis. It appears to be extremely virulent when present in the human peritoneal cavity. It does not produce the green pus in the peritoneum, such as is often seen in a local abscess. In fact, one is led to believe that virulent cultures of the bacillus which kill patients in a few days do not usually produce any chromogenic staining of the pus, although the same bacillus may produce large quantities of pigment when grown on artificial media. We have never yet seen green pus in the peritoneal cavity of man or animals, even after exposure of the exudate to the air for some minutes. We consider that the bacillus pyocyaneus will in the large majority of cases cause death when present in the peritoneal cavity, and is only less virulent than the streptococcus pyogenes in the fact that it takes a little longer to produce death.

The Bacillus Coli and its Relation to the Cause of Appendicitis.

In every variety of appendicitis which we have studied, the colon bacillus is the most important pathogenic organism in a large proportion of the cases. In nearly every instance, however, we have found more than one strain of this bacillus to be present, either in the abscess, peritoneal exudate, or elsewhere. This fact is very important, as the various strains of the bacillus coli isolated in each case have not the same pathogenic virulence. We have found that when this organism is present in the interior of the vermiform appendix in an interval case, although the acute illness may have subsided some weeks previously, yet the bacillus coli will be as actively pathogenic when tested experimentally, as a strain of the bacillus coli isolated from the peritoneal cavity during an acute attack of appendicitis. It follows from this observation, that if during an operation of appendicectomy in the quiescent period, the colon bacillus is allowed to escape into the peritoneal cavity, fatal peritonitis may ensue, in an exactly similar manner as if the operation had been done during the acute attack. In one instance, we isolated a virulent strain of the colon bacillus from a very small abscess situated in the wall of the appendix, just beneath the peritoneal coat. There had been no acute symptoms in this case for eight weeks previous to this operation, but yet the peritoneum might easily have been infected. This case gives definite support to a suggestion made by H. P. Hawkins in his classical monograph of 1895, namely, that certain instances of so called idiopathic peritonitis might be due to the rupture of minute abscesses, which had escaped observation, in the wall of the appendix.

Every one who has studied the literature of appendicitis, must have been struck with the fact that in nearly every instance in which the bacillus pyocyaneus has been isolated from a case of appendicitis, or in fact any case of peritonitis, the colon bacillus has been absent. We performed a large number of experiments which showed that the colon bacillus would not grow in the presence of the bacillus pyocyaneus, except under certain conditions, which are described in detail in another chapter.

The colon bacillus appears to be less virulent than the bacillus pyocyaneus when present in the peritoneal cavity in peritonitis, and is certainly much less virulent than the streptococcus pyogenes. If present alone in the peritoneal exudate "at a distance," then the prognosis is extremely grave, whilst if the phagocytes are all degenerated, then the prognosis is practically hopeless. If this organism is present together with the staphylococcus albus, then the prognosis is less grave, although still very bad; if, however, the staphylococcus albus has been present in the peritoneal exudate some hours before the colon bacillus, then a patient suffering from diffuse peritonitis has a far better chance of recovery.

CHAPTER IX

POST-OPERATIVE PERITONITIS

If the literature of the bacteriology of peritonitis as a whole is scanty, that of this particular form is, for obvious reasons, still more so. Excluding most of the cases in which the bacteriological examination has been made post mortem as being of little value, we are reduced to the few instances in which the examination has been made from material obtained at a second operation. In 1895, Cullen investigated four cases of fatal post-operative peritonitis, but unfortunately all post mortem. The operations were all pelvic ones, and proved fatal, two on the third day, one on the sixth, and one on the eighth. The organisms isolated were, in one case, the streptococcus pyogenes and the colon bacillus; in another, the staphylococcus aureus and the bacillus pyocyaneus; in the third, the staphylococcus aureus; and in the fourth, the staphylococcus aureus and albus. It should be noted that the cases in which the streptococcus pyogenes, bacillus coli, and bacillus pyocyaneus were found were the most rapidly fatal. These cases, occurring within a short interval of one another in the practice of one operator, were attributed to defective catgut. It is, however, difficult to believe that catgut which had undergone any sort of cleansing whatsoever could contain all these virulent organisms, and the fact that the material was obtained post mortem detracts from the value of the observation, but we are of opinion that these cases are really of the same class as one of hysterectomy in our series, in which the bacillus pyocyaneus was found, and which will again be referred to.

Manahan in 1903, investigating nineteen cases of peritonitis from various causes examined only one post-operative case ante mortem. This was a case of enterectomy for carcinoma, where the abdomen was reopened on the third day for peritonitis. Both films and cultures from the exudate showed the streptococcus pyogenes and the colon bacillus.

We have examined seven instances; six from material obtained at a second operation, and one within four hours of death. Of these cases two were local intraperitoneal abscesses, and the rest were instances of diffuse peritonitis.

Two cases of appendicectomy during a quiet interval.—The first concerned a man, thirty-one years of age, who had had two attacks of appendicitis, one seven months and one three weeks before admission. The appendix was removed fifteen days after admission. At this time no swelling could be felt, the pulse and temperature were normal, and the patient felt in perfect health. There were some vascular adhesions and a little cheesy material about the appendix, which was strictured and contained a concretion. The appendix was removed by the clamp method, that is without opening its lumen, and the abdomen was closed. On the same evening the pulse was 108 and the temperature 100·2°. Twelve hours later the pulse was 112, and the temperature 100·4°, and at midday on the second day they were respectively 132 and 101°.

The abdomen was now rigid and tender and gave a dull percussion note over the right iliac fossa. The patient vomited frequently and looked very ill. Twenty-two hours after the first operation the abdomen was reopened, when a condition of universal redness and distension of the intestines was found, whilst turbid odourless fluid bathed them everywhere, and flakes of lymph lay amongst the coils. The inflammation was most intense in the caecal region. There was no leakage from the buried stump. The abdomen was washed out and drained, and intravenous saline infusion performed, but death took place forty-four hours after the first operation. Films of the exudate showed enormous numbers of polynuclear cells, streptococci, and diplococci. Cultures from the caecal region and at a distance both gave a pure growth of the streptococcus pyogenes; anaerobic cultures remained sterile. Ten cubic centimetres of blood, taken from the basilic vein at the operation, gave a pure growth of the streptococcus pyogenes.

The second case occurred in a boy twelve years of age, who had had an appendix abscess drained two months previously. He returned from a convalescent home in perfect health and with the wound healed. The appendix was found free from adhesions, but strictured, and exhibiting the scar of an old perforation. It was removed by the clamp method, and the abdomen was closed. The peritoneum appeared perfectly healthy, and cultures taken from its surface proved sterile. Within a few hours the boy became extremely ill, and soon showed signs of diffuse peritonitis, which became worse with extraordinary rapidity. Death occurred forty hours after the operation. Films and cultures were taken four hours after death. The films showed endothelial cells only and no organisms. Cultures from the exudate and from the gut surface gave a pure growth of the streptococcus pyogenes. Unfortunately the blood was not examined in this case.

The strain of the streptococcus pyogenes obtained from the peritoneal cavity in the first case presented the typical cultural characters of this coccus. It formed very long chains when grown in broth, and stained well by Gram's method. The organism did not, however, grow, anaerobically. This is, of course, an exception to the general rule in the life history of the pyogenic cocci. This streptococcus was injected into the peritoneal cavity of a mouse and proved to be highly pathogenic. The organism was recovered from the spleen of the animal and was present in scrapings of this organ in very large numbers.

The strain of the streptococcus pyogenes which was isolated from the basilic vein was found to be similar in every detail to the organism which had been isolated from the peritoneal cavity in the same case.

It will be noticed that there were no organisms seen in the peritoneal exudate of the second case of streptococcic peritonitis. The streptococcus which was isolated in this instance was similar in most respects to the organism which had been obtained from the peritoneal exudate and from the patient's blood in the first case, but with these exceptions, namely, that this coccus was a facultative anaerobe, and that it was found to be non-pathogenic to mice. It has been frequently demonstrated that a streptococcus which has been proved to be highly pathogenic to man may yet fail to produce any effect in animals, and the case which we have just quoted is a good illustration of this fact. In the first of these examples the streptococcus which was highly pathogenic to mice failed to kill a rabbit, or even have any pathogenic properties. These facts are very important when we come to consider that one of the first anti-streptococcic sera which was placed on the market was obtained from a strain of the streptococcus pyogenes which had been isolated from one of the lower animals, and not from a human source.

The film preparations of the peritoneal exudate which were examined in both instances illustrate one very important point, namely, that the cells in the peritoneal cavity were found to be apparently healthy. It is true that in the second case we did not find any organisms, but in the first case large numbers of streptococci were present. If, however, we examine the cells present in the peritoneal cavity in a case of peritonitis due to the colon bacillus, both the polynuclear and mononuclear cells are always found to be degenerated. There may be some of the cells in a healthy state of preservation, but the large majority are degenerated beyond recognition. This fact cannot fail to be of importance; we know that the body cells are actively phagocytic in cases of peritonitis due to the colon bacillus, but only slightly so in those instances which are due to infections with the streptococcus pyogenes. It may be partly owing to this fact that in cases of peritonitis due to the streptococcus pyogenes death occurs so very rapidly; much more rapidly than in the case of any other known micro-organism.

With the colon bacillus free in the peritoneal cavity the prognosis is sufficiently bad, but with the streptococcus pyogenes it appears to be hopeless, and this in spite of the presence (as in one of these cases) of enormous numbers of phagocytes, which appear to be powerless against this virulent infection. We take the view that these cases are instances of infection at the operation, not from the stump of the appendix, but from outside. If we adopted the theory of stump infection, we should have to explain why the colon bacillus was not present; why two cases should have been due to an organism which is rarely found in appendicitis, but which, when present, is of greater virulence than even the most virulent colon bacillus; and why they should have recovered, the one from a "catarrhal" attack and the other from an abscess, and yet have retained within the appendix a streptococcus in such a state of virulence as to kill within forty-eight hours. Lastly, if these cases were due to a blood infection, it is hardly possible that there would be the evidence of intense peritonitis so very soon after the original operation. If, however, the infection of the peritoneum is the primary lesion, and the blood infection secondary, as we suggest, then we have an explanation of what we believe to occur in many fatal cases of peritonitis.

The Bacillus Pyocyaneus in Post-operative Peritonitis.

In a case of hysterectomy death was due to diffuse peritonitis caused by the bacillus pyocyaneus. Supravaginal amputation for fibromyomata had been done, and the after progress was satisfactory for three days, after which the temperature began to rise, and by the twentieth day there was a definite localised pelvic abscess. This was opened through the peritoneal cavity; its walls were formed partly by inflamed and distended intestine. The pus, which was thick and non-smelling, showed polynuclear cells, gram-positive cocci and bacilli, and gram-negative bacilli. The clear fluid present in the peritoneal cavity beyond the abscess proved to be sterile, whilst the pus gave, both aerobically and anaerobically, a pure growth of the bacillus pyocyaneus. Death from diffuse peritonitis occurred eight days after the second operation. The autopsy showed universal purulent peritonitis. Ten c.c. of blood taken from the basilic vein shortly before death grew the streptococcus pyogenes and the staphylococcus albus. In this instance the fatal infection of the peritoneum doubtless occurred by the opening of the abscess. Where the bacillus pyocyaneus came from in the first instance is doubtful. Possibly it was from the interior of the uterus, but more probably it came from the inflamed intestine which formed part of the wall of the abscess.

In another instance, the colon bacillus was found in a localised abscess after colotomy for acute obstruction. Death occurred from diffuse peritonitis.

We have three examples of staphylococcic infection. One had had gangrenous omentum removed from a strangulated hernia three weeks previously. The wound had been drained, had suppurated, and had then healed. A localised intraperitoneal abscess around the omental stump yielded the staphylococci albus, aureus and citreus. The patient recovered.

In another instance a large localised intraperitoneal abscess formed fourteen days after myomectomy. The pus yielded a pure culture of the staphylococcus aureus, and the patient recovered. In another case, enucleation of a necrotic uterine fibromyoma was followed fourteen days later by signs of diffuse peritonitis. The lower part of the abdomen contained a fibrino-purulent exudate from which the staphylococcus albus was obtained in pure culture both aerobically and anaerobically, whilst the films showed cocci only. The abdomen was washed out and drained. Death occurred three days later, and at the autopsy it was found that the peritonitis involved only the lower half of the abdomen.

CHAPTER X

SEPTICAEMIC PERITONITIS

We apply the term septicaemic to those cases in which the peritoneal infection is a secondary event, and due to organisms brought by the blood stream. Although there is no absolute proof, we consider that there is sufficient evidence to justify a belief in this manner of infection.

There is little doubt that pneumococcic peritonitis is most frequently an infection by means of the blood stream, and Dudgeon and Branson have shown this to be the case in most pneumococcic infections in children.

Streptococcic Peritonitis.

Of this variety of septicaemic peritonitis we have examined two cases. The first instance occurred in a child aged seven months, who was admitted for diffuse erysipelas. The whole cutaneous surface was, at one time or another, involved. On the tenth day of the illness, the symptoms and physical signs of peritonitis appeared, from which the child died within twenty-four hours. The peritoneal cavity was opened within twenty minutes of death. There was diffuse peritonitis present; the coats of the intestines were bathed in a large quantity of turbid, but non-offensive fluid. There was no attempt at agglutination of the intestines. Film preparations of the peritoneal exudate showed large numbers of polynuclear cells which were in an apparently healthy condition, and also large numbers of diplococci and streptococci, which stained by Gram's method. Many of the leucocytes were phagocytic, but we did not observe one single chain of cocci within the cells, only diplococci. No other micro-organisms were seen. A culture of the streptococcus pyogenes was obtained from the peritoneal exudate, and also of the colon bacillus. There was no injury or ulceration of the intestines to account for the presence of the colon bacillus, so we must conclude that this organism had made its way into the peritoneal cavity as soon as the patient died, or even during the death agony. This is a typical example of septicaemic peritonitis.

The second case occurred in a man aged fifty. This patient had been ill with acute abdominal symptoms for twenty-four hours before the operation. A large quantity of clear exudate was found in the peritoneal cavity, and an acutely inflamed mass covered with flakes of lymph in the great omentum. This tumour proved to be a round-celled sarcoma which had undergone inflammatory changes. The vermiform appendix was normal, and there was no intestinal lesion. The patient died three days after the operation.

Large numbers of polynuclear and mononuclear cells were present in the cover-slip preparations of the peritoneal exudate, but no micro-organisms. The fluid in the peritoneal cavity was found to be sterile, but the staphylococcus albus and aureus were obtained from the exudate near the inflamed sarcoma. A pure culture of the streptococcus pyogenes was obtained from the surface of the tumour.

It is very interesting to observe that although the streptococcus pyogenes was present on the surface of the tumour, we failed to isolate this organism from the peritoneal exudate.

Although there were large numbers of polynuclear cells in both these examples of streptococcic peritonitis, yet, these cells were apparently normal, and in neither instance contained any chains of cocci.

We have already drawn attention to this peculiar behaviour of the cells in this variety of peritonitis, which is quite different from what is found in cases where the infection is due to the colon bacillus, or to the bacillus pyocyaneus.

Mainier has recently recorded a case of peritonitis supervening upon erysipelas, in which he isolated the streptococcus pyogenes from the peritoneal exudate. McCollon and Blake have published two cases of peritonitis occurring during the course of an attack of scarlet fever. One of these concerned a boy, aged five, who developed the symptoms and physical signs of peritonitis on the twenty-eighth day of the illness. About 21 ounces of pus were drawn off from the peritoneal cavity by means of a trocar and cannula. A pure culture of the streptococcus pyogenes was obtained from this fluid. The day after the abdomen had been tapped the umbilicus ruptured and fluid escaped for several days, but the boy made a complete recovery.

A pure culture of the streptococcus pyogenes was also grown from the peritoneal exudate of a case which occurred in an adult man. The signs of peritonitis developed on the fourteenth day of a very severe attack of scarlet fever. At the autopsy, which closely followed the operation, pleuritis, otitis media, endocarditis, and diffuse peritonitis were found.

Few people would deny that all these published cases to which reference has been made were really examples of septicaemic peritonitis. We consider that peritonitis due to the streptococcus is generally a septicaemia. It would appear that in cases of peritonitis due to this organism there is hardly any local reaction at the seat of infection, such as always occurs in peritonitis due to the colon bacillus, bacillus pyocyaneus, and staphylococcus aureus. The streptococcus pyogenes is absorbed from the peritoneal cavity with such rapidity, that the patient is dead before the tissues and body fluids are able to offer any response to so vigorous an attack.

We shall only obtain satisfactory results in the treatment of this disease, when a valuable multivalent anti-streptococcic serum is discovered. It is extremely doubtful if more favourable results will ever be attained by surgical means.

Pneumococcic Peritonitis.

It is impossible to be certain of the origin of many cases of pneumococcic peritonitis, but it is highly probable that in the large majority of cases it is a blood infection. There is no doubt at any rate that this statement is true as regards this variety of peritonitis in children. There is one point, however, which still requires explanation, namely, how it is that the peritoneum is so much less frequently infected with this organism than are the other serous sacs. Some observers have found the pneumococcus in the peritoneal cavity in cases of pleuritis without any evidence of inflammation of the peritoneum.

If we study the literature of peritonitis we find that the pneumococcus, like the streptococcus pyogenes, is frequently stated to be present without sufficient evidence.

In 1886, Cornil described pneumococcic peritonitis for the first time, and since that paper was published, the subject has been very exhaustively dealt with, both in this country and abroad, but chiefly by French bacteriologists.

Our own series includes, in addition to one instance in which the pneumococcus was found in an appendix abscess, but not in pure culture, three instances of pure pneumococcic infection of the peritoneum. One case was operated upon, and in the other two the exudate was examined within twenty minutes of death.

The first example occurred in a male child, aged seven weeks, who had been ill for two days. There was oedema of the abdominal wall. Slight but distinct jaundice was present. The temperature was 100° and the pulse 120. No operation was done, and the child died on the third day of the illness. At the autopsy, a large quantity of greenish fluid was found, in which were suspended flakes of fibrin. A pure culture of the pneumococcus was obtained from this exudate. We failed, however, to find a source of infection.

The second case concerned a rickety male child, aged two-and-a-half years. At the autopsy, in addition to the peritonitis, which was diffuse but not of a very severe type, broncho-pneumonia, empyema, suppurative pericarditis, and lymphadenitis of the mediastinal glands were found. The peritoneal exudate was thick greenish-yellow pus. A pure culture of the pneumococcus was obtained from the pleura, pericardium, and from the surface of the lungs, but the peritoneal exudate was sterile. This example might be described as an instance of acute polyserositis.

The third case was one of extreme interest. It has been stated that certain Continental workers have taught that if, in a child suffering from peritonitis, intracellular, gram-negative diplococci are present in film preparations of the vaginal secretion, then operative interference is quite unnecessary, because that is regarded by them as sufficient evidence that the peritonitis is gonorrhoeal. The case which we are about to describe is sufficient proof that such a statement will not hold in every case. A little girl, aged six, was seized whilst at school with acute abdominal pain. The bowels were opened four times that day. Vomiting commenced on the following morning, and continued at short intervals for twenty-four hours. On admission, she looked extremely ill. The pulse was 140, and the temperature 103·2°, rising to 105·2° immediately before the operation. The abdomen moved well on respiration and was not distended, but was very tender on palpation. The lungs appeared to be normal. There were no signs of otitis or meningitis. The abdomen was opened forty-eight hours after the first symptoms had been observed. A small quantity of thin, odourless pus was present, in which strings of fibrin were suspended. The intestines were reddened but not distended, and the peritonitis was distinctly more marked in the lower half. The appendix was normal and the Fallopian tubes did not appear to be more inflamed than the rest of the pelvic peritoneum. The abdominal cavity was flushed out with hot saline solution and closed. Death occurred two hours later.

At the autopsy, the lungs were found to be normal, as also were the rest of the structures above the diaphragm. The meninges were normal. Besides the condition of diffuse peritonitis which was present, the uterus was found to contain about a drachm of pus.

Bacteriology.

Film preparations of the vaginal secretion, taken before the operation, showed large numbers of cocci, and diplococci, which failed to retain Gram's stain. The diplococci were chiefly intra-cellular, but also extra-cellular. The ends of the cocci were flattened and these ends were approximated.

Enormous numbers of polynuclear and mononuclear cells were present, in cover-slip preparations of the peritoneal exudate. Large numbers of gram-positive diplococci were also seen. These cocci were entirely extra-cellular. Exactly similar results were obtained with film preparations of the pus from the interior of the uterus, except that in this instance short chains of cocci were also present.

A pure culture of the pneumococcus was obtained from the peritoneal cavity and from the interior of the uterus. This organism was intensely pathogenic to mice. A capsulated diplococcus was obtained from the various viscera and blood of the infected mice. This case is, therefore, of exceptional interest. It is, as far as we know, the first instance in which the pneumococcus has been isolated from a case of pyometra. Whether the abscess in the cavity of the uterus was the primary focus, it is impossible to say, but it is not unlikely. A primary focus will be found, in most cases of pneumococcic infections in children, however, if the middle ears are carefully examined.

None of the cells in the peritoneal exudate in this case were degenerated, although the pneumococcus appeared to be extremely virulent. We know, however, that in the less acute cases of pneumococcic peritonitis, the leucocytes are actively phagocytic.

It is possible that the organism which was found in the vaginal exudate was the gonococcus, whilst the organism which produced the most important changes elsewhere was the pneumococcus. There were certain points as regards the morphology of the organism which were unlike the gonococcus, but these points are not as important as the fact that the organism was gram-negative, and was confined to the interior of the leucocyte. Whichever view we hold as to the nature of this organism, it is quite certain that, because gram-negative intracellular cocci are found in the vagina, they need not necessarily be the cause of the peritonitis arising in such a case.

CHAPTER XI

THE STAPHYLOCOCCUS ALBUS IN PERITONITIS

WE have considered it advisable to refer to the coccus which we have isolated from the peritoneal cavity in ruptured tubal gestation, appendicitis, and in all other varieties of peritonitis, as the white coccus, or the staphylococcus albus. The organism which was described by Rosenbach as the staphylococcus pyogenes albus, sometimes produces abscesses when injected subcutaneously into guinea-pigs and rabbits, and may produce septicaemia and pyaemia when inoculated intravenously into these animals. The white coccus which we isolated from our cases of peritonitis differed from Rosenbach's coccus as regards its pathogenicity and, therefore, it is perhaps advisable to omit the term "pyogenic" when referring to the coccus present in our cases. Professor Welch preferred to name the organism which he isolated from aseptic wounds, stitch abscesses, and also from the peritoneal cavity in a case of peritonitis, "the staphylococcus epidermidis albus." He considered that it was probably an attenuated variety of the staphylococcus pyogenes albus. We can do no better than follow in the footsteps of so eminent an authority as Professor Welch and omit the term "pyogenes."

TABLE SHOWING THE NUMBER AND VARIETY OF CASES FROM WHICH THE WHITE COCCUS WAS RECOVERED FROM THE PERITONEAL CAVITY IN PERITONITIS.

Table.	Nature of table.	No. of cases in each table.	No. of cases in which the white staphylococcus was isolated.	No. of cases in which a staphylococcus was present but not identified.
1	Ruptured Tubal Gestation .	17	17	0
2	Intra-peritoneal haemorrhage from other causes . . .	3	2	0
3	Salpingitis	8	1	1
4	Ovarian Cystitis . . .	3	2	0
5	Strangulated Hernia . . .	47	12	1
6	Intestinal Obstruction . .	53	24	2
7	Inflammation and perforation of the Hollow Viscera .	21	10	1
8A	Acute Appendicitis with diffuse non-perforative Peritonitis	11	4	0
8B	Acute Appendicitis with diffuse perforative Peritonitis	17	3	1
8C	Appendicitis with local abscess formation . . .	40	15	10
8D	Appendicitis: Complications	9	5	0
8E	Interval Cases of Appendicitis	16	10	1
9	Post-Operative cases of Peritonitis	7	2	0
10	Septicaemic Peritonitis . .	6	1	0
11	Exploratory Coeliotomy .	12	0	0
	TOTAL . .	270	108	17

Morphology.

This organism was found to be morphologically identical with the various types of staphylococci. It stained well by Gram's method and with the various aniline dyes. The individual cocci were smaller when the organism was grown anaerobically, and in these instances the cocci showed less tendency to retain Gram's stain.

Cultural Characters.

The organism was found to be a facultative anaerobe. It did not decolorise Weil's medium, and failed to produce gas in any medium containing glucose.

Broth.—Marked turbidity of the medium occurred, and a corkscrew-like deposit on shaking the culture tube was obtained in every case within a period of twenty-four hours.

Agar.—A pure white streak along the line of the needle, with irregular margins due to isolated colonies, was obtained on every occasion. In some instances the growth on agar was dry, but in the large majority of cases it was moist.

Jelly.—A growth was seen in every instance within twenty-four hours, which gradually increased. Liquefaction of the medium generally occurred about the second to the fifth day. In two examples we failed to obtain any liquefaction.

Neutral red jelly.—The cultural characters were similar to those which have been already mentioned in the case of ordinary jelly. The colour of the medium was changed to yellowish-brown in thirteen examples, a change which usually took place within eight days, at 22° C. The colour remained unchanged in eleven instances.

Litmus milk.—This was acidified in every instance, usually within forty-eight hours. It was generally thickened within forty-eight hours and clotted in three to four days. In three instances clotting did not take place until after the tenth day. In many instances, especially if the clotting was slight, the casein was gradually redigested.

Potato.—The growth on potato could seldom be described as luxuriant. Numerous white dots on the surface of the medium, which, after two or three days' growth, gradually formed a continuous streak, was of common occurrence. In a few instances only, a very slight growth occurred.

Neutral red broth.—This medium was employed in but a few instances, so that it is impossible to form any definite opinion as to its value. In most instances in which it was employed, we noticed that the neutral red colour was changed for a bright pink coloration.

Indol reaction.—This reaction was not present in those instances in which the test was employed. This of course refers both to young cultures in peptone water, and also cultures of six to ten days old.

Surface colonies on jelly plates.—Small but distinct colonies were recognized after twenty-four hours' growth, at 22° C. At the end of forty-eight hours' incubation, the colonies, when examined by direct light, were found to be small raised white points, and with transmitted light, were shown to have a distinct and regular margin, while each colony was definitely granular.

Pathogenicity.

Young broth cultures of the white occcus obtained from various cases of peritonitis were injected into the peritoneal cavity of animals. We usually noticed that the animals were ill for several hours, but usually were perfectly well within twenty-four hours. In some instances, inoculation of the coccus into the peritoneal cavity of guinea-pigs did not produce any obvious effect. We have shown, however, in another chapter, that the inoculation of this organism into the peritoneal cavity of guinea-pigs produces a large quantity of clear effusion within an hour of inoculation. Large numbers of phagocytes also take an active part in freeing the peritoneum from this coccus. These observations show that it is impossible to judge an inoculation experiment without a very exact autopsy. In some instances this organism was injected into the peritoneal cavity of guinea-pigs prior to an injection of the colon bacillus, with the most remarkable results, which are fully dealt with elsewhere.

Subcutaneous injection of the coccus into various animals seldom produced more than an inflammatory swelling of about forty-eight hours' duration. Occasionally the swelling subsided much more rapidly, without any obvious ill effect. In no instance, however, did suppuration occur.

An induration around the site of inoculation, in those cases in which the white coccus had been injected subcutaneously, was frequently noticed. We very much regret, that we failed to inject the white staphylococcus into the blood stream of rabbits, as this is often found to be a ready means of forming an opinion of the pathogenic properties of this coccus.

Agglutination Reactions.

Technique.—In every case a twenty-four hours' agar culture was employed. An emulsion was made with 0·85 per cent. normal saline solution; sometimes the coccus clumped spontaneously in this emulsion, but when the strength of the saline was decreased to 0·1 per cent., as suggested by Wright and Douglas in the case of the plague baccillus, this no longer occurred. A control experiment with normal blood serum was, of course, carried on during the whole period of each observation.

It is usually considered at the present day that complete loss of motility, and diffuse and "tight" agglutination within a period of thirty minutes with a dilution of 1 in 50, is diagnostic of typhoid fever. So far as we are aware, the agglutination reactions of the staphylococcus albus are unknown, whilst only a small amount of work has been published regarding agglutination experiments with the staphylococcus aureus. Otto concludes that of the many varieties of staphylococci, there is only one which is really pathogenic to man. This variety, he says, may easily be distinguished by its strictly specific agglutination reaction with the serum of an animal immunised against this pathogenic variety.

It is, however, generally recognized that pathogenicity and agglutination bear no constant relation to one another, and, therefore, for this, amongst other reasons, we cannot place any reliance upon these observations of Otto.

It is impossible, at present, to lay down any fixed rule as to what constitutes a positive or a negative staphylococcic reaction, and we have, therefore, been obliged, for the purposes of this work, to fix an arbitrary standard. We have tested the agglutination reaction of the staphylococcus albus, isolated from various cases of peritonitis, with the patient's own serum, and in certain instances with the serum of other patients, in forty-six cases. In twenty-six instances there was no reaction with a dilution of 1 in 10. In seven instances, well marked clumping of the cocci occurred with dilutions of 1 in 10, 1 in 20, and 1 in 50, within a period of one hour, and in one instance with a dilution of 1 in 100. In five examples, well marked clumping took place with a dilution of 1 in 10 and 1 in 20, but only a slight reaction was seen with a dilution of 1 in 50, within a period of sixty minutes. In four cases, good reactions occurred with dilutions of 1 in 10 and 1 in 20 within a period of one hour, but no reaction was obtained with a dilution of 1 in 50.

In two cases, there was only a slight reaction with dilutions of 1 in 10 and 1 in 20, in sixty minutes. In two examples, some reaction was obtained with dilution of 1 in 10, but not with any further dilution. None of these cocci, when tested with the serum of a normal person, gave any reaction whatever.

If we now turn to the length of time that the patients had been ill before the operation, and divide it into periods, a very striking result is obtained. In six cases the illness had lasted for less than six days, and none of these gave any reaction. In the twelve cases which gave a reaction with a dilution of 1 in 50, the length of history lay between six days and sixteen weeks. In the four which gave a good reaction with 1 in 20, but none with 1 in 50 dilution, the illness had lasted for from one to three months.

It is scarcely fair to compare two organisms differing so widely in their pathogenicity as the staphylococcus albus and the bacillus typhosus, but we may say that in one respect they resemble one another, namely in the agglutination reactions. A well-marked typhoid serum reaction rarely occurs before the tenth day of illness, and we see very much the same to be the case with the staphylococcus albus : no reaction was obtained in a case of less than six days' history.

H. S. D. Browne and K. Crompton, working in the Clinical Laboratory of St. Thomas's Hospital, obtained the following interesting results as to the length of time in which the typhoid agglutination reaction persists after an attack of typhoid fever.

With a dilution of 1 in 50, they found that there were only three instances in which the reaction was positive, seven months or more after the attack of typhoid fever. In 50 per cent, the reaction was positive in cases of one to six months after the attack, whilst a large number of the negative cases reacted to dilutions of 1 in 10 and 1 in 20. They considered a reaction to be positive, when complete loss of motility and diffuse " tight " agglutination occurred within a period of thirty minutes.

We do not know how long it may persist in cases of staphylococcus albus infection, but such evidence as we have leads us to the conclusion that the agglutinative properties may last some months, as in the case of patients who returned for appendicectomy several weeks after the healing of an abscess, and in whom the staphylococcus was still found to be present in the peritoneal cavity.

The case in which the best reaction was obtained was one of great interest. An appendix abscess had been opened eleven weeks previously, and had healed. The patient had been taken ill again three days before admission, and was found to be suffering from diffuse peritonitis. The staphylococcus albus, which was isolated from beyond the region which contained the colon bacillus, was rapidly and "tightly" agglutinated by the patient's serum. Recovery took place.

It is scarcely necessary to add that any lingering doubt regarding the staphylococcus albus as a possible contamination is finally disposed of by the agglutination reactions.

Staphylococcus albus: Agglutination tests.

Number of cases.	Dilution employed.	Nature of Reaction.
26	1–10	No reaction.
7	1–10, 1–20, 1–50 (In one instance a dilution of 1–100 was also employed)	Well-marked and diffuse agglutination within a period of one hour. The reaction always commenced immediately, with the weaker dilutions.
5	1–10, 1–20, 1–50	Similar to the above, except that with dilutions of 1–50, only a slight reaction occurred.
4	1–10, 1–20	Similar to the above results, except that no reaction was obtained with dilutions of 1–50
2	1–10, 1–20	Similar to the above, but the reaction very slight.
2	1–10	Some agglutination was obtained with this dilution, but not with any greater dilution.

CHAPTER XII

THE COLON BACILLUS.

Morphology.

THIS organism, when grown anaerobically, usually appeared as a small stout rod-shaped bacillus with rounded ends, whilst not infrequently it resembled a stout coccus. When cultivated under anaerobic conditions, it was usually longer and thinner, and occasionally the terminal ends of the bacillus were square instead of being rounded. We never observed any beading in the active and virulent strains of the colon bacillus which we met with. It was found to form short chains on only two or three occasions out of the many hundred cultures which were examined; in one instance (Fig. 7) the chains were of enormous length and were quite obvious, even with the low powers of the microscope. True capsule formation was not seen, but a pseudo-capsule was often observed in film preparations of the peritoneal fluid taken direct from an infected animal's body. We shall again refer to this pseudo-capsule when we come to discuss the pathogenicity of this organism.

Staining Reactions.

The well-known fact that the colon bacillus is gram-negative appears to be an almost constant rule. It was observed, however, that when the bacillus had been grown anaerobically it occasionally stained rather more darkly, and in one or two instances it retained Gram's stain, but only when kept under anaerobic conditions.

Thermal Death-point.

It was found that twenty minutes' exposure to a temperature of 59° C was sufficient to cause the death of the organism.

Motility of the Organism.

It is a generally accepted fact that the colon bacillus is in most instances a motile organism. Dr. W. G. Savage is most emphatic on this point; he says: "Motility is a fundamental character and too important to be used as a mere variety differentiator. It must, I think, be accepted that all true bacilli coli are motile." He considers that the colon bacillus when first isolated may be non-motile, but when grown on certain artificial media, motility will generally be observed to be present. We have tested those bacilli which are stated in this communication to be non-motile, and have found this to be constant, irrespective of the medium from which the organism was obtained. We did not obtain any motility by passing these non-motile strains of the bacillus through an animal, except on one or two occasions. The colon bacillus was definitely non-motile[1] in fifty-five cases out of a total of seventy-four. In seven instances, the bacillus was found to be actively motile, in eight examples it was sluggish, and in four cases motility was only just perceptible. The number of non-motile organisms in this series is very much higher than any which has yet been recorded. In those cases in which two or three strains of the colon bacillus were isolated from a loop of the same peritoneal exudate, each strain was carefully examined and, therefore, the sum total of colon bacilli referred to in this paper is very large.

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[1] A few very sluggishly motile bacilli might be seen in a hanging-drop preparation of a small percentage of these cultures, but only a very few.

Cultural Characters.

Broth.—In every instance, marked turbidity of this medium, and a thick flocculent deposit, were noticed at the end of twenty-four hours, at 37° C.

Glucose broth.—Each strain of the colon bacillus was found to grow well in this medium under anaerobic conditions, with well-marked gas production.

Weil's medium.—In every instance some alteration of colour was noticed, from a light green to a deep yellow, such as occurs during the growth of the bacillus aerogenes capsulatus. The colour rapidly returned when the culture was exposed to the air. Gas production was obvious in every instance.

Agar.—A thick dirty-white streak was seen on the surface of agar after twenty-four hours' growth, at 37° C. In some cases the growth was more extensive than in others, but every strain grew much more rapidly and more extensively than in the case of the bacillus typhosus.

Glycerine agar.—Cultural characteristics similar to those observed on agar.

Gelatine slant.—The various strains of the colon bacillus when grown in this medium, at 22° C., gave fairly uniform results. At the end of the first twenty-four hours the streak was bluish and translucent, but usually at the end of forty-eight hours it was opaque, whilst in every instance there was distinct opacity within a period of four days. We agree with Dr. Savage, that "all liquefiers of gelatine should be excluded as not true organisms," i.e. as not true bacillus coli. We have never found the colon bacillus to liquefy gelatine, even at the end of one month's growth.

Neutral red jelly slant.—Slight alteration of colour occurred in most instances within twenty-four hours, at 22° C. A yellowish-brown colour was noticed, usually in the upper portion of the tube, at the end of forty-eight hours' growth, and in most instances a green fluorescence could be discerned. Within a week the entire tube of gelatine was of a yellowish-brown colour.

Neutral red broth.—This medium was altered to a yellowish-brown colour within a period of twenty-four hours, in every instance, whilst not infrequently the colour of the medium was changed to a bright yellow. An obvious green fluorescence was present in every case.

Indol production.—A slight but distinct production of indol was obtained at the end of twenty-four hours' growth in peptone water, at 37° C. In forty-eight to seventy-two hours a very marked indol reaction was obtained. It is well known, however, that bacilli which may resemble the colon bacillus in almost every respect, may yet fail to produce indol. This especially refers to the strains of the colon bacillus obtained from sewage, shell-fish, water-supplies, and some other sources.

McConkey's medium. (Sodium-taurocholate, lactose, litmus, peptone water).—In every instance the various strains of the colon bacillus acidified and fermented this medium when incubated anaerobically at 42° C., for forty-eight hours. After a period of several days, sometimes weeks, the blue colour returns, which as Mr. S. G. Shattock has shown, is due to the formation of ammonia.

Litmus milk.—This medium was acidified and in most instances thickened in twenty-four hours, at 37° C. In a large majority of cases the milk was clotted in forty-eight hours. In those instances in which the colon bacillus failed to clot milk in forty-eight hours, it was found to be clotted within a period of three days. In no instance was the clot found to re-dissolve nor the alkalinity to return.

We examined the contents of the tubes in which the colon bacillus had been grown, and obtained a positive reaction for lactic acid. Dr. Savage has shown that the curdling of milk by the colon bacillus is due in almost all cases to the presence of an acid—presumably lactic acid. It is only in a few very doubtful cases that the curdling of the milk is due to an enzyme, and in these instances the curdling does not take place for some days. Curdling commences, according to Dr. Savage, when 33 per cent. of acid has been produced, and is complete when about 40 per cent. has been formed. He has also shown that those strains of the colon bacillus which coagulate milk less slowly than other strains produce less acid; for instance, the average amount of decinormal acid produced in those specimens of milk which are coagulated in less than twenty-four hours is less than 41, for those in more than twenty-four hours, but less than forty-eight, it is 40·3; for those coagulated in three or four days it is 39; and for those coagulated, but after a longer period than four days, it is 31·1.

Glucose agar shake.—Every strain of the colon bacillus was found to ferment the glucose and to split up the agar within twenty-four hours, at 37° C.

Glucose gelatine.—Results similar to those obtained in the case of glucose agar. It was noticed, however, that some strains of this bacillus produced much more gas in twenty-four hours than others.

Litmus cane-sugar jelly shake.—This medium was acidified in every instance within twenty-four hours, but only three strains of the colon bacillus were found to ferment this sugar. It would, therefore, appear that, with three exceptions, the variety of colon bacillus found in our cases from the human peritoneum belonged to the type described by Escherich.

Litmus mannite gelatine shake.—In every instance but one, the colon bacillus was found to ferment mannite and acidify the litmus within forty-eight hours. One strain, however, although it acidified litmus in twenty-four hours, failed to ferment either mannite, cane sugar, or maltose, while it rapidly fermented lactose and glucose, while in every other respect it resembled the so-called typical colon bacillus.

Litmus lactose gelatine shake. — Lactose was fermented in all instances but two. The gas production was much more marked with some strains than with others. In every instance, this medium was acidified within twenty-four hours. In the two examples in which lactose was not fermented even at the end of fourteen days' incubation, at 22° C, maltose, mannite, and glucose were fermented by these strains of the colon bacillus, whilst cane sugar was fermented by one of the strains, although not by the other.

Litmus maltose jelly shake.—This was acidified in every instance within twenty-four hours. Fermentation occurred in every case but two; in these instances, there was no evidence of gas production at the end of fourteen days' incubation, at 22° C. One of these strains of the colon bacillus also failed to ferment cane sugar and mannite, while the other strain fermented all the sugars except maltose.

Those strains of the colon bacillus which failed to ferment one or more of the sugars did not show any other cultural peculiarities.

It is universally recognised that one of the fundamental characters of the colon bacillus is that it ferments lactose. Dr. Savage is most emphatic on this point. He says: "Extended experience has convinced me of its fundamental importance, and I would reject all organisms as not true bacillus coli communis if they did not ferment lactose with production of acid and gas." These remarks are of great interest when we refer to our results of the fermentation of lactose by the colon bacillus. It can be readily understood that various strains of the colon bacillus isolated from river-mud, tidal water, springs, etc., may undergo certain changes which prevent the true cultural characteristics of the organism appearing until the bacillus has lived for varying periods in the bacteriological laboratory, but there is no reason why these cultural peculiarities should occur with the colon bacillus obtained direct from the human tissues in which it has been producing extensive pathological changes. We do not see sufficient reason to classify the two strains of the colon bacillus which did not ferment lactose as anything else but the colon bacillus. It is of interest, however, that the only two strains which failed to ferment this sugar, yet fermented glucose, mannite, maltose, and, in one instance, cane sugar.

Starch fermentation.—In no instance was starch fermented by any of these strains of the colon bacillus. The litmus was acidified, however, without exception. Dr. Eyre has found that the colon bacillus, when grown in litmus starch, usually produces sufficient acid to redden the litmus.

Potato.—In most instances the colon bacillus was found to grow extremely well on potato, producing an abundant dirty-white moist growth. In some cases the colour of the growth was deep yellowish-brown, in other instances a lighter yellow. In a small percentage of the cases the growth was white, and was a much less abundant growth than when darker in colour. In every instance, there was a good growth within twenty-four hours, at 37° C.

Phenol broth.—We used phenol broth of the following strengths with absolutely constant results—0·1 per cent., 0·25 per cent., 0·5 per cent. of carbolic acid. In every instance a good growth was obtained with the 0·1 per cent., but no growth was obtained with the stronger preparations, not even after several days' incubation, at 37° C.

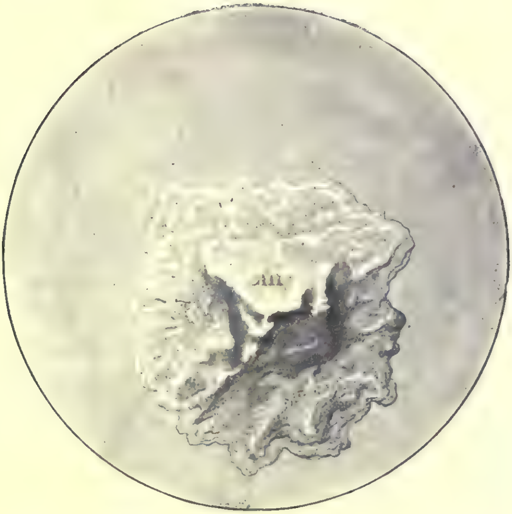

FIG. 9.—Surface colony of the colon bacillus, grown on gelatine for forty-eight hours, at 22° C. This type of colon colony more closely resembles a typhoid colony than any other. From a broth culture obtained from a case of peritonitis.
[*No. " A " eyepiece ; 1 inch obj.*]

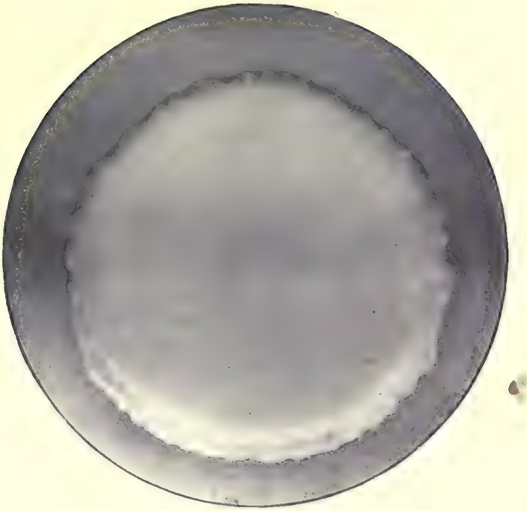

FIG. 10.—Common type of surface colony of the colon bacillus grown on gelatine. From a broth culture obtained from a case of peritonitis.
[*No. " A " eyepiece ; 1 inch obj.*]

Surface colonies on agar.—There is nothing characteristic of the appearances of the colonies of the colon bacillus growing on the surface of agar. They are usually moist, raised, dirty-white colonies, showing a slightly irregular margin and a dense opacity by transmitted light.

Surface colonies on the medium of Drigalski and Conradi.—In those instances in which this medium was employed, the colonies were moist, shiny, and "pink" coloured within a period of twenty-four hours. Some colonies which were pale blue for the first twenty-four hours, became "pink" at the end of forty-eight hours.

Surface colonies on gelatine.—There is little doubt that the most important cultural characters of this bacillus are the appearances of the surface colonies on gelatine. Dr. Savage has shown, in an elaborate paper on this subject, that these colonies may be of various shapes and sizes. We found, however, that every strain of the colon bacillus which we isolated from the peritoneum, presented either the appearance of the first type or second type of colony, such as are shown in the accompanying drawings (Fig. 9 and 10). In a few instances only one type of colony was observed, but this was the exception. In some cases, other types of colonies besides, or in place of, those which we have figured, were obtained. Dr. Savage has described twenty-eight varieties, but we have had no experience of the large majority of these colonies, although we did obtain colonies which resembled Nos. 2, 5, 8, 16, 23, 26 and 27, as illustrated in Dr. Savage's paper. These irregular colonies were seen in old cultures, but it appears from our observations that there are only two classes of coli colonies which are constantly present in cases of human peritonitis. It should be borne in mind that the irregular type of coli colony resembles the typhoid colony for the first twenty-four hours of growth, but after that period it bears no resemblance to the surface colonies of the typhoid bacillus on gelatine. We tested some hundreds of these regular and irregular specimens of coli colonies with positive typhoid serum, but failed, without exception, to obtain agglutination of the bacilli, even with a dilution as low as one in ten.

Agglutination Reactions.

Much work has been done on the agglutination of colon bacilli with typhoid serum, and the contradictory results which have been obtained are probably due to the fact that some observers consider that if agglutination of an organism occurs even with a dilution of 1:2, it is evidence that specific agglutinins are present. This may be so, but we must always remember that bacilli can often be agglutinated with normal serum, if very low dilutions are employed. Ever since Gruber and Durham published the results of their valuable experiments on typhoid agglutination, in 1896, and Widal and Grünbaum made a practical application of these experiments, serum-diagnosis has become a very important subject. It is surprising that the agglutination of colon bacilli with the serum of patients, other than those suffering from typhoid fever, has not been more fully investigated, when we consider the important part which the colon bacillus plays in human diseases. Widal considers that in any case of coli infection, it is only the specific strain of colon bacilli which will be clumped with the patient's serum. In our investigations, we have employed exactly the same technique as is employed in the Clinical Laboratory of St. Thomas's Hospital, for the serum diagnosis of typhoid fever. A twelve to twenty-four hours agar culture of the colon bacillus was employed in every experiment. Broth cultures were never used, because there is always some agglutination of the bacilli which are growing in the broth, and there is always a tendency of the bacilli to clump in the control test. A filtered emulsion of the bacilli in 0·85 per cent. normal saline was found to produce the best results. Dilutions of 1 : 10, 1 : 20 and 1 : 50 were employed in every instance. Lower dilutions were not used, as it is very questionable whether any importance can be attached to positive results obtained with these very low dilutions.

We tested the agglutinative property of the serum from sixty-eight cases of peritonitis upon the special strain of colon bacillus isolated in each instance. We also performed a large number of experiments with the serum from cases of chronic constipation due to various causes, cases of anaemia with septic stomatitis, and with the serum of patients suffering from typhoid fever. We also tested the serum from animals which had died of peritonitis due to experimental inoculation with the colon bacillus, on the culture of the bacillus which had caused the death of the animal, and which had been isolated from its peritoneal cavity or from its heart blood. Although we performed these experiments on the bacilli obtained from some thirty inoculated animals, we failed to obtain any reaction with a dilution of 1 : 10, in a single instance. It was hardly to be expected that a positive reaction would be obtained when we remember that the animals were dead in every case within twenty-four hours, and a reaction with a dilution of 1 : 10 is seldom obtained in the first forty-eight hours of typhoid fever.

In fifty-two of our sixty-eight cases of peritonitis, we failed to obtain any reaction with a dilution of 1 : 10. In five examples, some slight agglutination was obtained with this low dilution, but none with a dilution of 1 : 20. In six instances we obtained a reaction with dilutions both of 1 : 10 and 1 : 20. In three of these cases, the colon bacillus which had been isolated from the patient was found to be non-motile.

The results of these experiments can best be understood if expressed in a tabulated form.

Dilution.	No. of Cases.	Type of Agglutination.	No. of Cases.	Type of Agglutination.
1 : 10	3	Marked agglutination, and slight loss of motility in thirty minutes.	3	Enormous clumps had formed within thirty minutes No loose bacilli.
1 : 20		ditto.		Similar result in two cases, but less marked in one.

In every instance but one we failed to obtain any reaction with a dilution of 1 : 50, and in this example a higher dilution was not employed.

In one case, the patient's serum produced very marked clumping of his own colon bacillus, and also marked loss of motility with dilutions of 1 : 10 and 1 : 20, but only a very slight reaction took place with a dilution of 1 : 50. In four instances we obtained a reaction which would be described as diagnostic of typhoid fever, namely, complete agglutination of the bacilli with dilutions of 1 : 10, 1 : 20 and 1 : 50 within a period of thirty minutes (Fig. 8).

In three of these cases the bacilli were non-motile, but in the one example in which the bacillus was motile complete loss of motility occurred.

In all these sixteen examples in which more or less reaction took place, we failed to produce any agglutination or loss of motility of these bacilli with the serum derived from cases of typhoid fever, chronic constipation, anaemia with oral sepsis, or with the serum derived from the other cases,

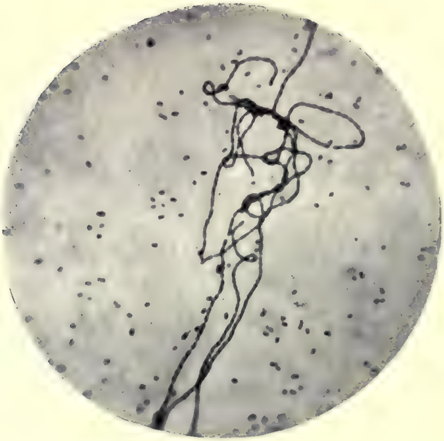

FIG. 7.—Pure culture of the colon bacillus forming immense chains. Obtained from a tube of broth which had been inoculated with a loop of peritoneal exudate from a case of peritonitis. Culture tube had been incubated at 37° C., for twenty hours. Specimen stained with dilute carbol-fuchsin.
[*No. "B" eyepiece ;* $\frac{1}{12}$ *oil-immersion.*]

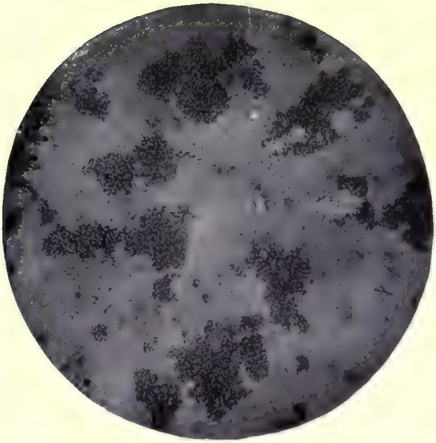

FIG. 8.—Clumps of colon bacilli agglutinated with patients' own serum. Dilution 1 in 50. Film preparation fixed and stained by Professor Leishman's method.
[*No. "B" eyepiece ; "D.D." obj.*]

which had already been shown to possess specific agglutinins. It is thus evident that the reaction in each instance was a specific reaction, and that the bacilli isolated from these cases must have had a specific effect. We might mention, here, that contrary to many observers, we have failed with a dilution of 1 : 10 to produce agglutination of the colon bacillus with positive typhoid serum, without exception, although we have made the attempt with very large numbers of strains of colon bacilli, and with very many specimens of positive typhoid serum.

Beyond the fact that all the cases which gave reactions with dilutions of 1 in 20 and 1 in 50 were cases of appendicitis, we cannot trace any factor common to them all. Five were abscess cases, all of which recovered ; three were instances of diffuse peritonitis, all of which proved fatal ; two were cases operated upon during a quiet interval after a recent acute attack ; and the last was a case of only twenty hours' history, with early gangrene, which recovered.

THE BACILLUS PYOCYANEUS.

Morphology.

This bacillus is a fine rod-shaped bacillus, usually rather shorter than the colon bacillus, but very much thinner. In fact, it resembles the colon bacillus grown under anaerobic conditions. The organism is actively motile, much more so than the large majority of motile typhoid cultures. It is flagellated at one pole. It is never capsulated, but may show a pseudo-capsule, such as we see in the case of the colon bacillus when film preparations have been made of the peritoneal exudate of an animal which had succumbed to the effects of this organism.

It never stains by Gram's method. It does not stain well with the ordinary aniline dyes.

Cultural Characteristics.

The bacillus produces a beautiful green colour, about the colour of young grass, when growing on the surface of potato. It is, however, peptone water which is most suitable for the development of its chromogenic properties. There is *never* any production of *pigment* in cultures of this organism, when grown under *anaerobic conditions.* The light green colour which is seen on the surface of potato and which also diffuses through the substance of agar gradually changes to a brown colour as time advances, finally becoming a dark olive colour in the agar, and producing a dark brown growth on the surface of potato.

Broth.—The bacillus grows readily in this medium at 37° C., forming a large flocculent deposit in the broth tube after forty-eight hours' incubation. Only a slight green colour is produced under these conditions.

Peptone Water.—It is in this medium, as we have already stated, that the bacillus pyocyaneus produces the most perfect colouration, more so than any other condition. If a culture of several months' standing on agar is sub-planted in peptone water, a light green colony will be produced in twenty-four hours.

Colour Tests.—We have already stated that the most marked colouration is obtained when this organism is growing in peptone water. If we add chloroform to the peptone solution, and then shake violently, the chloroform takes up the pigment, which is then a distinct greenish-blue. If an acid is now added (a few drops of a weak mineral acid) the green colour disappears and is replaced by a pink colour[1] which is itself altered to the original colour by the addition of an alkali.

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[1] It will then be seen that it is impossible to recognize the indol reaction in the case of this bacillus, as any acid converts the green to a pink colouration.

The true green colouration is not seen when the organism is grown in broth, at least, not if the growth is abundant, but if the broth is violently shaken a distinct green colouration is at once produced.

Potato.—This bacillus grows well on potato, and a diffuse green colouration diffuses throughout the medium. As time advances a brownish moist growth is seen on the surface of this medium.

Agar.—The organism grows well on agar, very rapidly spreading over the surface of the agar slope, whilst the chromogenic property is very well developed throughout this medium.

Jelly.—A pale bluish-white growth forms along the line of the needle in this case, the streak presenting an irregular wavy margin. Liquefaction commences within twenty-four to thirty-six hours, and very rapidly extends throughout the medium.

Neutral Red Jelly.—The colour of this medium is altered at the end of twenty-four hours' growth, at 22° C. A greenish fluorescence diffuses throughout the medium, and very soon it is of a greenish yellow colour.

Glucose Jelly Shake.—Liquefaction begins at the uppermost limits of the jelly shake, and gradually extends throughout the jelly. The green colouration also follows the line of liquefaction. Gas production occurs, but is sometimes well marked, at other times very slight.

Litmus Cane Sugar Jelly.—This medium is acidified in twenty-four hours, and is gradually, but rapidly, liquefied. We failed to obtain any evidence of gas formation.

Litmus Lactose Jelly.—Well marked production of gas occurred in twenty-four hours, otherwise the changes were similar to those obtained in the case of cane sugar.

Maltose Litmus Jelly.—The results which we obtained were identical to those obtained in the case of the litmus lactose jelly.

Weil's medium.—A good growth was obtained, under anaerobic conditions, at 37° C. A brownish yellow colouration developed at the end of forty-eight hours.

Litmus Milk.—This was rapidly acidified and thickened, whilst at the end of forty-eight hours the milk became a solid brownish clot. The clot was very rapidly liquefied.

Egg albumen.—A thick green growth was obtained in forty-eight hours, and the medium was liquefied in five days.

Surface Colonies on Gelatine Plates grown under aerobic conditions.—Large pale almost translucent colonies appeared at the end of twenty-four hours, which presented a granular centre and a wavy spreading periphery. Liquefaction of the colonies commenced at the centre within twenty-four hours.

Surface Colonies on Agar.—Large pale green colonies, most of which are almost transparent. The margin is irregular and spreading, whilst the centre is denser and granular.

Odour of the bacillus pyocyaneus.—This is usually very strong, and can best be compared to the odour of water in which green vegetables have been boiled.

Although we have described the most important morphological and cultural characters of this bacillus, we have still to mention one or two further points before we refer to the relation which it bears to the bacillus coli.

It has been stated by several observers that the bacillus pyocyaneus is an obligatory aerobe, but this statement is incorrect. The organism grows well under anaerobic conditions, but as already mentioned, does not produce any pigment. It has also been stated that it retains Gram's stain, but this view also appears to be erroneous. The organism is generally considered to be actively motile, but if it is grown under anaerobic conditions, the motility is much less than when it is grown aerobically.

We must now refer to the various statements which have been made as to the pathogenicity of this bacillus. Professor McFarland considers that this organism is feebly pathogenic. Dr. Bulloch stated at a meeting of the Pathological Society of London, that the bacillus was one of the most virulent of all known micro-organisms for the ordinary laboratory animals. He also mentioned that he had frequently observed suppurative cerebro-spinal meningitis in rabbits inoculated with this bacillus. Few observers have referred to the pathogenicity of this bacillus for man. We have found it to be highly pathogenic when present in the peritoneal cavity of man, and other observers have also found it to be so in other situations, but on the other hand it may present only the most feeble pathogenicity. The bacillus is also extremely virulent when injected into the peritoneal cavity of guinea-pigs, but to a much less extent when injected subcutaneously. It appears that various cultures differ as to their pathogenicity, for whilst one strain of this bacillus may produce a rapidly spreading haemorrhagic oedema when injected subcutaneously into guinea-pigs, and death in twenty-four hours or even less, another culture of the organism may only cause a localized abscess. The same thing evidently happens in the case of man.

J. T. Eastman and T. V. Keene have recently published a case of pyocyaneus septicaemia originating in a septic traumatic lesion of the arm. The bacillus was cultivated from the blood, and the patient recovered after a long illness.

The relation of the Bacillus Pyocyaneus to the Colon Bacillus.—If we refer to the literature of appendicitis, we shall find that in most of the cases of appendix abscess from which the bacillus pyocyaneus was isolated, the colon bacillus was not found, and we have obtained exactly the same results. In the five cases of peritonitis from which we isolated the bacillus pyocyaneus, we failed to cultivate the colon bacillus. This must, therefore, be due to some special circumstance and not to a mere chance.

If a culture tube of broth is inoculated with both the organisms in question, at the same time, and then the tube is incubated for twenty-four hours, and then plated out, we shall only obtain colonies of the bacillus pyocyaneus. If the bacillus coli is added to a growth of the bacillus pyocyaneus or vice versa, we obtain identical results.

It was found that with the various strains of bacillus coli and bacillus pyocyaneus[1] at our disposal, neither type of bacillus would grow in phenol broth of greater strength than 0·1 per cent., and if a tube of this strength of phenol broth was inoculated with the colon bacillus and the bacillus pyocyaneus simultaneously, incubated for twenty-four hours at 37° C., and then plated on the surface of agar, however great a dilution was employed, only the bacillus pyocyaneus was obtained.

When ½ c.c. of a twenty-four hours' culture of the colon bacillus and the bacillus pyocyaneus was inoculated into the peritoneal cavity of a guinea-pig, the animal was dead from peritonitis in eighteen hours, but although numerous methods were employed, only the bacillus pyocyaneus was cultivated from the peritoneal cavity of the animal.

Many attempts were made to isolate the colon bacillus when the same experiments were carried out under anaerobic conditions, but they failed in every instance. It was thought probable, that if filtered cultures of the bacillus pyocyaneus were inoculated with the bacillus coli and the bacillus pyocyaneus, and if the cultures were then plated, only the bacillus coli would be cultivated, but in these experiments, as in all the others, we failed to cultivate the colon bacillus, and obtained only the bacillus pyocyaneus, although the colon bacillus had previously been found to grow well in the toxins of the bacillus pyocyaneus. In fact, whatever methods were employed, the colon bacillus was never recovered in the presence of the bacillus pyocyaneus. We must, therefore, come to the conclusion that the bacillus pyocyaneus, *but not its toxins,* exert an inhibitory influence on the colon bacillus. The result of these experiments is fully borne out in the bacteriological laboratory, in the tissues of animals, and in the tissues of man. Dr. Boycott has kindly drawn our attention to some experiments which he has recently performed in connection with these organisms. He has been able in every case to isolate *both* organisms, either from the peritoneal fluid of animals, or from tubes inoculated with both organisms. We have repeated our experiments with the same cultures of the bacillus pyocyaneus *which had been in the laboratory some months* since we had obtained them from the human peritoneum, and have arrived at the same results as did Dr. Boycott. It is, therefore, a matter of very great interest, more especially owing to these later experiments, but it still requires an intelligent explanation.

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[1] Virulent strains of the B. Pyocyaneus, which had quite recently been isolated from the exudate in acute peritonitis, were used.

Bacillus Pyocyaneus Agglutination Reactions

The methods employed in this reaction were exactly similar to those used in the case of the colon bacillus. We tested the agglutinative property of the patient's serum in four out of the five cases from which we had isolated the bacillus pyocyaneus. In three instances we failed to obtain any reaction, even with a dilution of 1 in 10, but in one case (71 B) an excellent reaction was obtained. The patient's serum produced large diffuse clumps of the bacilli, and almost complete loss of motility within a period of thirty minutes with a dilution of 1 in 20, whilst with a dilution of 1 in 50 good diffuse clumping and some loss of motility was seen within a period of one hour. Although this reaction would not be considered as positive in the case of typhoid fever, yet it is an extremely good reaction, and shows that the patient had produced specific agglutinins for this special strain of bacilli. The presence of specific agglutinins in animals' serum for special strains of bacillus pyocyaneus has been demonstrated by previous workers on this subject, but we cannot recall any previous experiments having been made on the action of human serum on the bacillus pyocyaneus isolated from the same case as that from which the serum was obtained. One of us has made numerous experiments with the serum of patients suffering from pyocyaneus infections, but has only once previously obtained a reaction, even with a dilution as low as 1 in 10. The bacilli isolated from the peritoneal cavity of our positive case were not isolated with the serum obtained from other cases of pyocyaneus infections. In no instance did we obtain any agglutinative reaction with the serum of animals which had been inoculated with this bacillus.

The patient whose serum gave such a well-marked reaction with the bacillus pyocyaneus obtained from her own abscess lived for twenty-seven days after the primary operation. A localised pelvic abscess was opened through the peritoneal cavity, on the twentieth day after hysterectomy. The pus yielded a pure culture of the bacillus pyocyaneus. The serum for the reaction was taken two days after this second operation.

CHAPTER XIII

PATHOGENIC PROPERTIES OF THE BACILLUS COLI AND BACILLUS PYOCYANEUS ISOLATED FROM CASES OF ACUTE ABDOMINAL DISEASE

No. 1. *Case* 1. Ovarian cystitis (Table IV, 59B).

1 c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 400 grammes. Death in eighteen hours.

Post-mortem examination. — Diffuse peritonitis. Large amount of sticky fluid in peritoneal cavity. Large amount of fibrinous pus chiefly over the surface of the liver. Surface of intestines dull and injected. Some free gas in belly cavity. No fluid in pleural sacs. Retro-peritoneal fat swollen.

Hanging-drop of peritoneal exudate.—Bacilli present in enormous numbers. Non-motile. Phagocytic reaction well marked. Cover-slip preparations of the peritoneal exudate were stained by Gram's method. Bacilli were gram-negative. Cells degenerated beyond recognition. Pure culture of the colon bacillus recovered from the belly cavity.

Staphylococcus albus—Bacillus coli.

1 c.c. of a imilar culture to the above was injected into the peritoneal cavity of a guinea-pig which had received twenty-four hours previously 1½ c.c. of a twenty-four hours' broth culture of the staphylococcus albus into the peritoneal

cavity. The animal was very ill for about two days, but *completely recovered.* Alive and well one month after the injection.

No. 2. *Case* 3. From the sac-fluid of a strangulated hernia (Table V, 91A).

1½ c.c. of a twenty-four hours' broth culture of the colon bacillus were injected into the peritoneal cavity of a guinea-pig. Animal died in twenty-four hours.

Post-mortem examination.—Diffuse peritonitis. Large amount of sticky fluid in peritoneal cavity. Large amount of pus present on the under surface of the liver and diaphragm. Haemorrhagic oedema at site of inoculation. No fluid in pleural sacs.

Hanging-drop of peritoneal exudate.—Bacilli numerous. Polynuclear cells present in enormous numbers. Pure culture of the colon bacillus recovered from the peritoneal cavity.

No. 3. *Case* 7. Strangulated internal hernia: peritoneal exudate (Table VI, 23A).

1 c.c. of a twenty hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 359 grammes. Animal dead in eighteen hours.

Post-mortem examination.—Diffuse peritonitis. Very little sticky fluid in peritoneal cavity. Small amount of fibrinous pus on the under surface of the liver and diaphragm. Intestinal surface and general peritoneum very much injected. Abdominal muscles soft. No fluid in pleural sacs.

Hanging-drop of peritoneal exudate.—Bacilli present in enormous numbers. Phagocytic reaction well marked. Colon bacillus isolated in pure culture from the peritoneal cavity of the guinea-pig. Bacillus was non-motile.

Animal's serum had no agglutinative action on the colon bacillus isolated from the animal's peritoneal cavity.

No. 4. *Case* 9. Perforated typhoid ulcer of intestine (Table VII, 64A).

1 c.c. of a twenty hours' broth culture of the colon bacillus (Colony No. 2) was injected into the peritoneal cavity of a guinea-pig weighing 400 grammes. Death in twelve hours.

Post-mortem examination.—Diffuse peritonitis. Large quantity of thick sticky fluid in belly cavity. Large amount of fibrinous pus on under surface of liver and diaphragm. Intestinal peritoneum and general peritoneum very much injected. Similar fluid in both pleural sacs to that present in the peritoneal cavity. Retro-peritoneal fat very much swollen.

Hanging-drop of peritoneal exudate.—Bacilli present in very large numbers and non-motile. Phagocytic reaction extremely well shown. Pure culture of the colon bacillus isolated from the peritoneal cavity of the guinea-pig.

Staphylococcus albus—Bacillus coli.

1 c.c. of a twenty-four hours' culture of the colon bacillus, similar to the above, was injected into the peritoneal cavity of a guinea-pig, which twenty-four hours previously had received one cubic centimetre of a twenty-four hours' culture of the staphylococcus albus into the peritoneal cavity. The animal was ill for a few days, but completely recovered. It was killed eighteen days later, but nothing abnormal was found at the autopsy except marked loss of weight.

No. 4. *Case* 9. (*continued*). Perforated typhoid ulcer of intestine (Table VII, 64A).

1 c.c. of a twenty-four hours' culture of the colon bacillus

(Colony No. 3) was injected into the peritoneal cavity of a guinea-pig. The animal was very ill for several days, but completely recovered. It was killed twenty days later, but nothing abnormal was found at the autopsy except a very marked loss of fat.

No. 5. Perforated typhoid ulcer (Table VII, 92B).

1 c.c. of a twenty hours' broth culture of the colon bacillus (Colony No. 2) was injected into the peritoneal cavity of a guinea-pig weighing 400 grams. Death in twelve hours.

Post-mortem examination.—Exactly similar to No. 4.

Hanging-drop of peritoneal exudate.—Bacilli present in enormous masses, not clumped. Non-motile. Very few cells seen, and these were phagocytic. Pure culture of the colon bacillus isolated from the peritoneal cavity.

Same case (Colony No. 3).

Similar inoculation experiment. Animal acutely ill for several hours, and then gradually recovered. Killed twenty-one days later.

Post-mortem examination.—Marked wasting. Nothing else abnormal found.

Staphylococcus albus—Bacillus coli (Colony No. 2).

Similar inoculation experiment repeated on an animal which had, twenty-four hours previously, received 1½ c.c. of a twenty-four hours' broth culture of a staphylococcus albus. Animal very ill for several hours, but gradually recovered. Killed twenty-one days later.

Post-mortem examination.—Marked wasting. No other abnormality.

No. 6. Colon bacillus from the interior of a gangrenous appendix of twenty hours' history (Table VIII*a*, 69B).

1 c.c. of a twenty-four hours' broth culture of the

colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 537 grms. Death in eighteen hours.

Post-mortem examination.—Similar to No. 4, except that there was no fluid above the diaphragm.

Hanging-drop of peritoneal exudate.—Bacilli present in enormous numbers. Non-motile. Phagocytic reaction well marked. Pure culture of the colon bacillus isolated from the peritoneal cavity.

Staphylococcus albus—Bacillus coli.

Similar experiment repeated on an animal weighing 437 grms., which had twenty-four hours previously received 1 c.c. of a twenty-four hours' broth culture of a staphylococcus albus. Animal very ill. Gradually improved, but ultimately died five days later.

Post-mortem examination.—Body extremely wasted. No evidence of retro-peritoneal fat, which is always considerably swollen in the acute cases. No evidence of peritonitis. No lymph to be seen. No obvious enlargement of lymphatic glands. No collection of pus anywhere. Nothing abnormal above the diaphragm.

A *Hanging-drop* preparation was made from the minute amount of fluid which was present, but no micro-organisms were seen. No leucocytes seen. Enormous masses of small and large globules present, which were shown to be fat by the "Scharlach R" stain.

Stained film preparations were made from the same fluid. No polynuclear cells seen, but large numbers of endothelial cells which contained gram-positive cocci and gram-negative bacilli. A staphylococcus albus and the colon bacillus were cultivated from the peritoneal fluid.

No. 7. Colon bacillus from the interior of an acutely inflamed appendix of forty-eight hours' history (Table VIII*a*, 82B).

½ c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 441 grms. Death in twenty-four hours.

Post-mortem examination.—Exactly similar to No. 6.

Hanging-drop of the peritoneal exudate.—Exactly similar to No. 6.

Staphylococcus albus—Bacillus coli.

Similar experiment repeated on an animal weighing 350 grms. with twice the dose of the culture used in the preceding experiment. This animal had twenty-four hours previously received an intra-peritoneal injection of 1 c.c. of a twenty-four hours' culture of a white staphylococcus. It was acutely ill for twenty-four hours, then rapidly improved, but after a few days became worse again, and finally died eleven days later.

Post-mortem examination.—Great congestion of sub-peritoneal vessels, and the peritoneum was dull and thickened. No trace of fluid. Close to the spleen there was an intraperitoneal abscess containing inspissated pus. Film preparations of this pus showed degenerated phagocytes containing gram-negative bacilli. The colon bacillus and a staphylococcus albus were cultivated from the general peritoneal cavity.

On examination of the chest, suppurative pericarditis was present, and the connective tissue of the mediastinum was found to be infiltrated with a large amount of gelatinous exudate. Film preparations of the pus from the pericardium showed large numbers of polynuclear cells, most of which were degenerated, but all contained gram-negative bacilli. A pure culture of the colon bacillus was obtained from it.

No. 8. Colon bacillus from the pus round an acutely inflamed appendix of a few days' history (Table VIII*a*, 74B).

1 c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 540 grms. Death in twelve hours.

Post-mortem examination.—Similar to No. 7, except that there was turbid fluid in each pleural sac.

Hanging-drop of peritoneal exudate.—Enormous masses of bacilli in clumps. Non-motile. Phagocytic reaction well marked.

Pure culture of the colon bacillus obtained from the peritoneal exudate.

No. 9. Colon bacillus from the turbid fluid round an acutely inflamed appendix of thirty-six hours' history (Table VIII *b*, 74).

Similar experiment to No. 8, with exactly the same result. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 10. Colon bacillus from the pus round a gangrenous appendix of five days' history (Table VIII*b*, 96A).

Similar experiment to No. 9, with exactly the same result.

No 11. Colon bacillus from the fluid round a gangrenous appendix of forty-three hours' history (Table VIII*b*, 8B).

Similar experiment to No. 10, with exactly the same result. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 12. Colon bacillus from the pus round a gangreno appendix of four days' history (Table VIII*b*, 11B).

Similar experiment to No. 11, with exactly the same result. Animal's serum did not produce agglutination with the colon bacillus isolated from its peritoneal cavity.

No. 13. Colon bacillus from the pus round a gangrenous appendix of three days' history (Table VIII*b*, 28B)

Similar experiment to No. 12, with exactly the same result, except that there was no fluid in either pleural sac. Sections of the diaphragm showed enormous numbers of gram-negative bacilli in the sub-endothelial lymphatics. (Fig. 5.)

Staphylococcus albus—Bacillus coli.

1 c.c. of a twenty hours' broth culture of this colon bacillus, and 1 c.c. of a twenty hours' culture of a staphylococcus albus obtained from the peritoneal cavity of a case of ruptured tubal gestation (Case 24B), were simultaneously injected into the peritoneal cavity of a guinea-pig. Animal extremely ill for about twenty-four hours, gradually improved, and finally recovered. Killed three weeks later. Nothing abnormal found except marked wasting.

No. 14. Colon bacillus from the pus round a gangrenous appendix of forty-eight hours' history (Table VIII*b*, 54B).

Similar experiment to No. 12, with exactly the same result, except that there was no fluid in either pleural sac.

No. 15. Colon bacillus from the pus round a perforated appendix (Table VIII*b*, 77B).

½ c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 600 grms. Death in eighteen hours. Result similar to No. 14.

Staphylococcus albus—Bacillus coli.

1 c.c. of the same culture as the above was injected into the peritoneal cavity of a guinea-pig which, twenty-four hours previously, had received 1½ c.c. of a culture of the staphylococcus albus isolated from the peritoneal cavity of a case of ruptured tubal gestation. Animal was ill for several days, but finally recovered. Killed one month later· Except for marked wasting, nothing abnormal found.

No. 16. Colon bacillus from the pus of an appendix abscess of ten days' duration (Table VIII*c*, 98A).

½ c.c. of a twelve hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig. Death in twenty-three hours.

Post-mortem examination.—Great distension of abdomen. Diffuse peritonitis. Small amount of very sticky turbid fluid present in peritoneal cavity. Intestines greatly distended, intensely reddened, and adherent. Diaphragm very injected. No free gas in peritoneal cavity. Retro-peritoneal fat swollen, Similar fluid in left pleural sac.

Hanging-drop of peritoneal exudate.—Bacilli present in enormous numbers, clumped, non-motile. Phagocytic reaction well marked. Pure culture of the colon bacillus recovered from the peritoneal cavity.

No. 17. Colon bacillus from the pus of an appendix abscess of five days' duration (Table VIII*c*, 1B).

Similar experiment to No. 16, with exactly the same result. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 18. Colon bacillus from the pus of an appendix abscess of three days' duration (Table VIII*c*, 10B).

Similar experiment to No. 17, with exactly the same result, except that there was no fluid in the pleural sacs. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 19. Colon bacillus from the pus of an appendix abscess of nine days' duration (Table VIIIc, 12B).

Similar experiment to No. 18, with exactly the same result. The colon bacillus was obtained in pure culture from the heart blood of the animal. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 20. Colon bacillus from the pus of an appendix abscess of fourteen days' duration (Table VIIIc, 37B).

¼ c.c. of a twenty hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 420 grms. Death in twenty-six hours. Post-mortem appearances exactly the same as in No. 16.

Peritoneal exudate.—In film preparations stained by Gram's method, some of the bacilli showed intense polar staining with a clear central portion. These appearances have also been noticed on other occasions.

Staphylococcus albus—Bacillus coli.

1¼ c.c. of a twenty hours' broth culture of this colon bacillus, and 1¼ c.c. of a twenty hours' broth culture of a white staphylococcus isolated from the peritoneal cavity of a case of peritonitis due to appendicitis (Case 31B), were simultaneously injected into the peritoneal cavity of a guinea-pig. Death in forty-eight hours. Post-mortem appearances similar to those obtained after injection of the colon bacillus alone.

No. 21. Colon bacillus from the pus of a large gas-containing appendix abscess of seven weeks' history (Table VIII*c*, 66B).

Similar experiment to No. 18, with exactly the same result.

No. 22. Colon bacillus from the pus of an appendix abscess of five days' history (Table VIII*c*, 72B).

1 c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 407 grms. Death in twenty-four hours. Post-mortem appearances the same as in No. 16, except that both pleural sacs contained turbid fluid.

Staphylococcus albus—Bacillus coli.

1 c.c. of a similar culture to the above was injected into the peritoneal cavity of a guinea-pig, which, twenty-four hours previously, had received 1 c.c. of a twenty-four hours' broth culture of the staphyloccus albus isolated from the peritoneal cavity in a case of ruptured tubal gestation (Case 52B). The animal was ill for several days, but ultimately recovered.

No. 23. Colon bacillus from the pus of an abscess of the abdominal wall, ten days after irrigation of the abdomen for perforative appendicitis (Table VIII*d*, 74).

½ c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 240 grms. Death in eighteen hours. Post-mortem appearances exactly the same as No. 22. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 24. Colon bacillus from the pus of a minute abscess in wall of quiescent appendix. Last attack eight weeks previously (Table VIII*e*, 5B).

1 c.c. of a twenty-four hours' broth culture of the colon

bacillus was injected into the peritoneal cavity of a guinea-pig weighing 615 grms. Post-mortem appearances exactly the same as in No. 18. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

No. 25. Colon bacillus from the interior of an appendix in which an acute attack had terminated nine days previously (Table VIII*e*, 23B).

½ c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighting 252 grms. Death in twelve hours. Post-mortem appearances as in No. 18. Animal's serum did not produce agglutination of the colon bacillus isolated from its peritoneal cavity.

Staphylococcus albus—Bacillus coli.

1 c.c. of a similar culture to the above was injected into the peritoneal cavity of a guinea-pig which, twenty-four hours previously had received 1 c.c. of a twenty-four hours' broth culture of a white staphylococcus isolated from the peritoneal cavity in a case of ruptured tubal gestation (Case 21). The animal was ill for twenty-four hours, and then rapidly recovered.

Another experiment.—½ c.c. of both the foregoing broth cultures were simultaneously injected into the peritoneal cavity of the same animal four days later. The guinea-pig was ill for forty-eight hours, but completely recovered.

No. 26. Colon bacillus from the interior of an appendix which had, one week previously, been the seat of a sub-acute inflammation (Table VIII*e*, 60B).

1 c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-

pig. Death in twenty-four hours. Post-mortem appearances as in No. 18. A pure culture of the colon bacillus was isolated from the heart blood of the animal.

Staphylococcus albus—Bacillus coli.

Equal quantities (1¼ c.c.) of twenty-four hours' broth cultures of the same colon bacillus and the staphylococcus albus isolated from the peritoneal cavity of a case of ruptured tubal gestation (Case 84B) were injected into the peritoneal cavity of a guinea-pig. The animal was ill for several days, but completely recovered. Animal killed one month later. Except for marked wasting no other changes were seen.

No. 27. Colon bacillus from the interior of an appendix which had been the cause of an abscess four months previously (Table VIII*e*, 79B).

1 c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 591 grms. Death in nineteen hours. Post-mortem appearances exactly the same as in No. 18.

Staphylococcus albus—Bacillus coli.

Equal quantities (1½ c.c.) of twenty-four hours' broth cultures of the same colon bacillus, and of a staphylococcus albus isolated from the peritoneal cavity in a case of appendicitis (Case 97), were simultaneously injected into the peritoneal cavity of a guinea-pig weighing 383 grams. Death in sixteen hours. Post-mortem appearances the same as in the previous experiment. Only the colon bacillus was cultivated from the peritoneal cavity.

No. 28. Colon bacillus from the interior of an appendix which had been the cause of a diffuse peritonitis eight months previously (Table VIII*e*, 76B).

¼ c.c. of a twenty-four hours' broth culture of the colon bacillus was injected into the peritoneal cavity of a guinea-pig weighing 410 grms. Death in twenty hours. Post-mortem appearances exactly the same as in No. 22.

Staphylococcus albus—Bacillus coli.

1 c.c. of a similar culture to the above was injected into the peritoneal cavity of a guinea-pig, which, twenty-four hours previously, had received 1 c.c. of a twenty-four hours' broth culture of the staphyloccoccus albus isolated from the peritoneal cavity in a case of appendicitis (Case 97). Animal was ill for forty-eight hours, but completely recovered. Killed one month later. Post-mortem examination showed nothing except marked wasting.

Staphylococcus albus—Bacillus coli.

Another Experiment.—Equal quantities (1½ c.c.) of twenty-four hours' broth cultures of the same organisms used in the previous experiment, were simultaneously injected into the peritoneal cavity of a guinea-pig weighing 330 grms. Death in twelve hours. Post-mortem appearances were the same as in the first experiment. A pure culture of the colon bacillus was obtained from the peritoneal cavity.

PATHOGENICITY OF THE BACILLUS PYOCYANEUS.

No. 1. Bacillus pyocyaneus from a case of post-operative peritonitis after hysterectomy (Table IX, 71B).

1 c.c. of a twenty-four hours' broth culture of the bacillus pyocyaneus was injected into the peritoneal cavity of a guinea-pig weighing 626 grms. Death in nineteen hours.

Post-mortem examination.—Diffuse peritonitis. Large amount of faintly blood-stained brownish fluid in the peritoneal cavity. Intestinal peritoneum very much injected, but intestines not distended. Large amount of pus distributed throughout the general cavity, especially on the under surface of the liver and diaphragm. Retro-peritoneal fat swollen. Similar fluid in both pleural sacs.

Hanging-drop of peritoneal exudate.—Motile bacilli present in enormous numbers. Phagocytic reaction slight. Cover-slip preparations of the exudate were stained by Gram's method. Bacilli were gram-negative. Cells degenerated beyond recognition. A pure culture of the bacillus pyocyaneus was isolated from the peritoneal cavity.

Another experiment.—½ c.c. of a thirty-six hours' broth culture of the bacillus pyocyaneus obtained from the peritoneal cavity of the guinea-pig was injected subcutaneously into the left leg of another guinea-pig. A large abscess developed at the site of inoculation. The animal became extremely ill, and was killed one week later. There was marked wasting, and a large gangrenous abscess in the leg from which the bacillus pyocyaneus was obtained in pure culture.

No. 2. Bacillus pyocyaneus from the pus of an appendix abscess of thirteen days' history (Table VIIIc, 18).

1 c.c. of a twenty hours' broth culture of the bacillus pyocyaneus was injected into the peritoneal cavity of a guinea-pig weighing 537 grms. Death in twelve hours.

Post-mortem examination.—Haemorrhagic oedema at site of inoculation in abdominal wall. Diffuse peritonitis. Large quantity of thick fluid in peritoneal cavity. Intestinal peritoneum very much injected. Intestines distended and adherent. Large amount of pus on under surface of liver and diaphragm. Retro-peritoneal fat swollen. Similar fluid in both pleural sacs.

Hanging-drop of peritoneal exudate.—Enormous masses of bacilli chiefly in clumps, showing sluggish motility. Only a few degenerated phagocytes seen. A pure culture of the bacillus pyocyaneus was obtained from both pleural and peritoneal exudates. Animal's serum did not produce agglutination of the bacillus pyocyaneus isolated from its peritoneal cavity.

No. 3. Bacillus pyocyaneus from the pus of an appendix abscess of four days' history (Table VIIIc, 71).

½ c.c. of a twenty hours' broth culture of the bacillus pyocyaneus was injected into the subcutaneous tissues of a guinea-pig's leg. Animal became very ill, and an abscess formed at site of inoculation. Killed a few days later. Marked wasting. Albumen and granular casts in the urine.

No. 4. Bacillus pyocyaneus from the peritoneal exudate in a case of appendicitis of three days' history (Table VIII*a*, 45).

1 c.c. of a twenty hours' broth culture of the bacillus pyocyaneus was injected into the peritoneal cavity of a guinea-pig weighing 485 grms. Death in twelve hours.

Post-mortem examination.—Diffuse peritonitis. Large amount of turbid brownish fluid in peritoneal cavity, in which were floating flakes of pus. Intestinal peritoneum extremely injected. Free gas in peritoneal cavity. Retroperitoneal fat swollen. Similar fluid in each pleural sac.

Hanging-drop of peritoneal exudate.—Exactly similar to No. 3. Serum test also similar.

A SUMMARY OF THE PATHOGENIC PROPERTIES OF THE B. COLI AND B. PYOCYANEUS AND OF THEIR TOXINS

The Colon Bacillus

The strains of colon bacillus used in the inoculation experiments were obtained from the following sources. Seventeen cases of purulent exudate around the appendix, whether localised or diffuse; in five cases from the interior of quiescent appendices; in two cases from the peritoneal exudate after the perforation of a typhoid ulcer; in one instance from the sac of a strangulated hernia; in one case from the interior of an acutely inflamed ovarian cyst; once from the peritoneal exudate in acute intestinal obstruction; and once from an abscess of the abdominal wall after appendicectomy.

In each case, from a quarter to one cubic centimetre of a young broth culture of the bacillus was injected into the peritoneal cavity of a guinea-pig. Death occurred in from twelve to twenty-four hours. The post-mortem appearances were similar in every case. Diffuse peritonitis was present, usually with a small amount of thick sticky fluid. Pus was present in every case on the under surface of the liver and diaphragm. The intestines were usually distended and reddened. Free gas in the peritoneal cavity was noted in a few instances. The retro-peritoneal fat was always swollen. In twelve instances fluid was present in the pleural sacs similar to that in the peritoneal cavity. Hanging drops of the peritoneal exudate always showed large masses of non-motile bacilli, which were occasionally lying in clumps. Numerous phagocytes, very much degenerated, were constantly present. In film preparations of the exudate stained by Leishman's method the bacilli showed a pseudo-capsule. Not infrequently the bacilli exhibited bipolar staining. The colon bacillus was obtained in pure culture from the peritoneal exudate in every case, and from the pleural effusion. In those cases in which cultures were made from the heart blood, the bacillus was also obtained.

No agglutination with the animal's serum was obtained in any case.

In seven instances a preliminary injection of a young culture of a staphylococcus albus was found to afford protection against a proved virulent culture of the colon bacillus inoculated into the same peritoneal cavity twenty-four hours later.

In another instance, in a precisely similar experiment, the staphylococcus albus was found to afford protection for five days. At the autopsy, there was no evidence of peritonitis, nothing abnormal above the diaphragm, and no organisms or phagocytes were seen in the minute drop of peritoneal exudate which was present. The animal was markedly wasted. In stained film preparations large numbers of endothelial cells were seen to contain both cocci and bacilli. The staphylococcus albus and the colon bacillus were cultivated from the peritoneal cavity. In yet another experiment, carried out in the same manner, the animal died eleven days later. There was an intraperitoneal abscess, from which were cultivated the staphylococcus albus and the colon bacillus; and suppurative pericarditis due to the colon bacillus.

Simultaneous inoculations of equal quantities of a virulent colon bacillus and a staphylococcus albus were made into the peritoneal cavity of six guinea-pigs. In one instance death occurred in twelve hours; in another in sixteen hours; in a third in forty-eight hours. Three of the animals recovered. When killed some weeks later nothing was found except marked wasting.

Inoculation of Coli Toxins.

When 1½ cubic centimetres of the mixed filtrates of several strains of the colon bacillus were inoculated into the peritoneal cavity or into the subcutaneous tissues of guinea-pigs, the animals rapidly and markedly wasted.

SUMMARY: PERITONITIS IN ANIMALS

THE BACILLUS PYOCYANEUS

The bacillus pyocyaneus used in the inoculation experiments was obtained from three cases of appendicitis and from one case of post-operative peritonitis. Inoculated into the peritoneal cavity of a guinea-pig this organism produces a rapidly fatal diffuse peritonitis. When injected subcutaneously a gangrenous abscess resulted, and marked wasting of the animal.

Inoculation of Pyocyaneus Toxins.

Ten cubic centimetres of the mixed filtrates of several strains of this bacillus were injected into two rabbits, without causing any obvious effect, and the animals were alive and well three months later.

CHAPTER XIV

THE RÔLE OF THE PHAGOCYTES IN PERITONITIS

We have made a preliminary investigation on Phagocytosis, a subject of such great importance in peritonitis. One of us, in conjunction with Dr. Ross, intends to publish a detailed study of Phagocytosis at a later date.

We undertook these experiments for the purpose of determining which cells play the most important part in the protection of the body against micro-organisms which were introduced into the peritoneal cavity at definite periods. In this preliminary investigation, we have only studied phagocytosis as it concerns the colon bacillus and staphylococcus albus.

We are able to show that the coarsely granular eosinophil cell, which some have considered to be non-phagocytic, and others only slightly so, to be one of the most important, if not the most important phagocyte in the early stages of peritoneal infection, whilst the finely granular polynuclear cell becomes, as is already well known, the important phagocyte in the later periods of peritonitis.

The result of these investigations will be more easily understood by giving a short account of each experiment.

Experiment 1.—One and a half cubic centimetres of a twenty-four hours' broth culture of the staphylococcus albus were injected into the peritoneal cavity of a guinea-pig; the animal was killed twenty-four hours later, and the peritoneal fluid was examined.

Fresh drop of peritoneal fluid. Enormous numbers of phagocytes present. Very small amount of free fluid. No signs of peritonitis to the naked eye.

Film preparations of the peritoneal fluid stained by Leishman's method.

	Total No.	Percentage	
Finely granular, polynuclear cells	424	84·8	
Small mononuclear cells	1	0·2	73 : 14·6
Large mononuclear cells	72	14·4	
Large hyaline cells	1	0·2	
Coarsely granular eosinophiles	1	0·2	
Transitional cells	1	0·2	
	500	100%	

The finely granular polynuclear cell in the guinea-pig's blood corresponds to the polynuclear neutrophil in human blood, and are similar, except that the granules in the guinea-pig's blood are eosinophilic. Most of the large mononuclear cells were vacuolated, and most of the polynuclear cells were degenerated, whilst all these cells and the large mononuclear cells were phagocytic. Numerous endothelial cells were present in the film preparations, but they were not included in the differential count.

Experiment 2.—One and a half cubic centimetres of a twenty-four hours' broth culture of the staphylococcus albus were injected into the peritoneal cavity of a guinea-pig; the animal was killed fifteen minutes later and the peritoneal fluid was examined.

A large amount of perfectly clear fluid was present in the peritoneal cavity.

A hanging-drop of the peritoneal fluid showed large numbers of leucocytes which were apparently phagocytic.

Film preparations of the peritoneal fluid stained by Leishman's method.

	Total No.	Per-centage.
Fine granular, polynuclear cell	8	2
Small mononuclear cells	103	25·75
Large mononuclear cells	75	18·75
Coarsely granular eosinophile cells	214	53·5

No less than 131 of the coarsely granular eosinophilic cells were phagocytic, while many of these cells contained many cocci.

Experiment 3.—One and a half cubic centimetres of a twenty-four hours' broth culture of the staphylococcus albus were injected into the peritoneal cavity of a guinea-pig ; the animal was killed an hour later and the peritoneal cavity was examined immediately after death.

A large amount of clear fluid was present. No signs of peritonitis visible.

A hanging-drop of the peritoneal fluid showed large numbers of leucocytes, many more than were present in a drop of the fluid from the guinea-pig's peritoneum in Experiment 2.

Film preparations of the peritoneal fluid stained by Leishman's method.

	Total No.	Per-centage.
Small mononuclear cells	345	86·25
Large mononuclear cells	50	12·5
Finely granular, polynuclear cells	2	0·5
Coarsely granular eosinophiles	3	0·75

Every variety of cell was phagocytic.

Experiment 4.—The animal (guinea-pig) was killed two hours after an exactly similar proceeding, as occurred in the previous experiments.

Much more fluid was present than in the case of the preceding experiment. The peritoneal fluid was found to be slightly turbid.

A hanging-drop of this peritoneal fluid showed large numbers of leucocytes.

Film preparations of the peritoneal fluid stained by Leishman's method.

	Total No.	Percentage.
Finely granular, polynuclear cells	458	91·6
Small mononuclear cells	22	4·4
Large mononuclear cells	1	0·2
Coarsely granular eosinophiles	19	3·8

Nearly every finely granular polynuclear cell was found to be phagocytic, while eight of the coarsely granular eosinophiles were also phagocytic.

Experiment 5.—A guinea-pig was killed one hour after an intra-peritoneal injection (½ a c.c.) of the colon bacillus.

There was hardly any peritoneal fluid present. A hanging-drop of the peritoneal exudate showed large numbers of leucocytes which were apparently phagocytic.

In this case the phagocytic reaction was extremely well marked, but every cell was *degenerated* beyond recognition.

Experiment 6.—A guinea-pig was killed four hours after an injection of a similar dose of the colon bacillus as in the preceding experiment, but another strain of the bacillus was used.

The peritoneum was injected in this case, and a good deal of peritoneal fluid was present.

Film preparations of the peritoneal fluid stained by Leishman's method.

	Total No.	Percentage.
Finely granular, polynuclear cells	245	61·25
Small mononuclear cells	53	13·25
Large mononuclear cells	21	5·25
Mast cells	11	2·75
Coarsely granular eosinophiles	70	17·5

Twenty-eight of the coarse eosinophiles were phagocytic, and eight of the small mononuclear cells. Every finely granular polynuclear cell was phagocytic, but all were degenerated

Experiment 7.—This animal was killed fifteen minutes after receiving an intra-peritoneal injection of a twenty-four hours' culture of the staphylococcus albus.

The peritoneal fluid which was examined immediately after death was found to be in large amount, and quite clear. There was no evidence of peritonitis. Hanging-drop preparation of the peritoneal fluid showed a large number of cells which were apparently phagocytic. We did not observe any extra-cellular cocci.

Film preparations of the peritoneal exudate stained by Leishman's method.

	Total No.	Percentage.
Finely granular, polynuclear cells	0	0
Small mononuclear cells	293	73·25
Large hyaline cells	14	3·5
Coarsely granular eosinophiles	93	23·25

Forty-eight of the coarsely granular eosinophiles were phagocytic. Many of the lymphocytes, both small and large, and the large hyaline cells were also found to be phagocytic.

As a result of these few experiments on phagocytosis, we have been able to show that many of the leucocytes which are present in normal blood play a very important part in peritoneal infections. It is impossible to form any absolute conclusions from so few experiments, but it is quite evident that the staphylococcus albus provokes an extensive phagocytosis within a period of fifteen minutes of injecting the organism into the peritoneal cavity, and that as time advances the cells increase in number; but instead of the mononuclear cells and eosinophiles being the chief phagocytes, the polynuclear cells with fine eosinophilic granules play the chief part in the protection of the body. The phagocytes, however, in the case of the staphylococcus albus, are in good condition after many hours of warfare with the micro-organisms, but the colon bacillus may cause a very rapid degeneration of leucocytes within one hour of peritoneal infection; in every instance, the colon bacillus provokes a rapid and extensive phagocytosis, almost entirely of the finely granular polynuclear variety. This bacillus, however, causes, as already stated, a rapid and extensive degeneration of the leucocytes, a circumstance which is not repeated in the case of the white coccus until a great many hours have elapsed.

We are, now, in a position to realize the harm that may be done when the peritoneal cavity is washed out in cases of peritonitis, more especially in those instances in which there is a staphylococcus infection of the peritoneum beyond the limits of the virulent colon bacillus. If we wash away these cells from the peritoneal cavity with large quantities of saline solution, we allow many micro-organisms to remain in the peritoneal cavity, to say nothing of carrying the colon bacillus into fresh regions of the peritoneum, but we replace these phagocytes and body fluids, which are actively engaged in the defence of the body against their powerful opponents, with a comparatively valueless fluid.

In the light of Prof. von Mikulicz's experiments, already referred to, it is asserted by some that the leaving of saline solution in the peritoneal cavity at the end of a flushing operation will do good by provoking a leucocytosis. But we must recollect that the experiments of von Mikulicz were made upon the healthy peritoneum; and, more than that, in cases of peritonitis any leucocytosis of which the body is capable will already have been provoked, in a far more powerful manner than salt solution is capable of, by the infection itself.

We have only one more point to which we wish to draw attention, namely, the phagocytic properties of the eosinophile (coarsely granular) and the small lymphocyte. We were most careful in these experiments to avoid drawing the cover-slip over the surface of the omentum; we only used the free fluid in the peritoneal cavity. There can no longer be any doubt, not only that the small lymphocyte is phagocytic, but that the eosinophile possesses phagocytic properties of the very greatest importance.

CHAPTER XV

TREATMENT OF ACUTE PERITONITIS, BASED UPON ITS BACTERIOLOGY

It will be seen that the term "acute peritonitis" embraces a number of inflammatory diseases which differ widely in their symptoms, course, and prognosis. The main factors in these, as in inflammatory diseases of the cellular tissue, are the variety and virulence of the organism which has produced the disease, and the power of resistance which the individual possesses against it. Unfortunately, there is no opportunity of ascertaining what this organism is, in any given case, until after the operation, so that we can only act upon the knowledge of what are the organisms most frequently present in any given class of cases.

In gastric and duodenal perforations, in intraperitoneal haemorrhage, and in pelvic inflammations, the organisms are, in the great majority of cases, of a mild type. In intestinal necroses, on the other hand, it is the virulent colon bacillus which is by far the most common organism. The streptococcus pyogenes and the bacillus pyocyaneus are so uncommon, and so uniformly fatal whatever the treatment adopted, that, for practical purposes, they may be disregarded.

It is undoubtedly true that peritonitis of bacterial origin can subside without operative interference.

From what we have seen of the bacteriology of the peritoneum around an inflamed appendix, it is impossible to believe that in all cases of appendicitis which subside without operation the peritoneum is sterile. We also believe that in the cases which ultimately culminate in abscess formation, the peritonitis was at one time diffuse, although no doubt of mild type and slight extent. But such terminations are not events to be reckoned upon, for at the beginning of an attack we can only conjecture what the bacterial infection may be, and certainly none can foretell the result. The earlier operation is undertaken, therefore, the less likely is the peritoneal infection to reach a desperate stage.

There are few, at the present day, who do not accept this view, but there is still a wide difference of opinion regarding the extent of the operation which should be performed. Whilst there are those who advocate the most extreme measures of washing, assisted by evisceration, there are others, notably John Murphy, who do not employ such drastic procedures. We are of opinion that the extent of the operation required depends upon the bacteriology of the case.

In streptococcic peritonitis, which is the most acute and fatal form that we know, it is doubtful whether any surgical procedure offers a prospect of success, but if there is any chance, it must lie in the *most thorough possible washing*. At least this treatment can do but little harm, for the infective exudate is carried with such rapidity over the peritoneal surface that there is little risk of spreading it over an unaffected area, whilst the phagocytes, which often appear to be powerless against this virulent infection, may be washed away without robbing the patient of what, in other forms of peritonitis, usually constitutes his chief line of defence. Peritonitis due to the bacillus pyocyaneus is of very little less virulence than streptococcic, but it is of rare occurrence, and is impossible to detect at the time of operation. In this form, as in the other, the same line of treatment would offer the only possible chance of success, if indeed recovery from this infection is possible.

In the vast majority of cases, however, it is the colon bacillus which is the chief infective agent, and therefore, most cases of peritonitis of intestinal origin must be treated as cases of colon bacillus infection. We believe that, from the observations which have been set out in preceding chapters, limited operations should be the rule, because of the mechanical impossibility of cleansing the peritoneum, the risk of washing away the phagocytes in the exudate beyond the area of most intense inflammation, and the danger of spreading infection over unaffected regions.

Upon this point the conclusions to which our research has led us are indentical with those arrived at by a large and increasing number of surgeons as the outcome of practical experience. Quite recently Mr. Charters Symonds has written as follows :—" Since I have adopted the plan of free incision and dry mopping, the results have greatly improved. In borderland cases operated upon on the 5th and 6th day I am certain that flushing will turn the scale to a fatal issue. . . . irrigation is unnecessary, and I believe also adds additional dangers in all cases, especially in the form now under consideration (i.e. a third day case)."

In local treatment, the question between *local* irrigation and dry-sponging is of relatively small importance. We are inclined to believe, however, that dry-sponging, so long as it is carried out with gentleness, is better than irrigation, because fluid poured into the abdomen is likely to carry infection beyond the area already involved. If those remote regions are already infected, then no amount of washing is likely to be of much avail.

In the case of mild infections, particularly those due to gastric perforations and intraperitoneal haemorrhage, the washing should be thorough, with a view to removing the foreign material present, such as the contents of the stomach or blood clot.

The question of *drainage* is one upon which much has been written, but a great deal of the literature applies to the earlier days of abdominal surgery, and concerns, not only septic cases, but all intraperitoneal operations.

In mild diffuse infections, such as gastric perforations, intraperitoneal haemorrhage, and the early stages of the peritonitis of obstruction, the organisms are comparatively harmless, and can be safely dealt with by the peritoneum. It is the rule in such cases where the abdomen has been closed without drainage, for the wound to heal by primary union.

In severe diffuse infections, on the other hand, there may be said to be more reason for drainage, although one sees many cases recover without even suppuration of the abdominal wall. In many cases of local abscess the conditions are quite different. There is a definite cavity, which, for practical purposes, is extra-peritoneal, and which can be drained. But where the peritonitis is diffuse, the possibility of drainage depends upon the integrity of the peritoneum. In cases where fibrinous deposit is absent, or insignificant, as in the gastric perforations, it is possible to drain, but where there is a sticky exudate present, drainage becomes impossible, because in a surprisingly short time the tube, or other form of drain, becomes surrounded by agglutinated intestine and omentum, and its track becomes merely a sinus, a sinus, moreover, which is not without danger, because extraneous organisms, particularly from the skin, have been found to extend with remarkable facility along such tracks. The objection of leaving a weak spot in the abdominal wall also is of some moment.

We are, therefore, presented with the paradox that, apart from local abscesses, the cases which it is most advisable to drain are the very ones where drainage is impossible, whilst those where it is possible, it is also unnecessary. In cases of gastric perforation where a tube has been left in the pelvis, a large amount of fluid may be discharged during the first one or two days, but in appendicitis cases treated in the same manner, it is remarkable how little fluid soils the dressings.

Next in importance to the operative technique in peritonitis comes the question of *drug treatment.* It is universally recognized that opiates should never be given before a diagnosis has been made, on account of the concealment of important symptoms. But when once a diagnosis has been arrived at, it is quite a common thing to see opiates given. If, rightly or wrongly, the decision has been arrived at not to operate, then the same objection still holds good, because, when the patient is under the influence of opiates, changes of vital importance, which may at any moment occur, are apt to escape notice. But there is an objection of little less importance than these, which applies after as well as before operation. In obstructed or inflamed bowel the colon bacillus attains its maximum of virulence, and in all probability, under these conditions is able to make its way out at points other than the primary focus. It has yet to be proved that intestinal movements play any very important part in the spread of infection over the peritoneal surface. On the other hand, intestinal paralysis spells death, for it is of vital importance that the infective material shall be eliminated from the bowel at the earliest possible moment. *A dose of morphia, superadded to the toxic paresis* *of the bowel, may just turn the balance against recovery.* Even more important is the effect of morphia upon the phagocytes. In this place we can give no details, but can only refer to the work on Phagocytosis, to which allusion has already been made. In that work, by one of us (L. S. D.) in conjunction with Dr. Ross, shortly to be read before the Pathological Society of London, it is shown that morphia has a marked inhibitory effect upon leucocytosis.

It is, therefore, obvious that the teachings of bacteriology harmonise with those of clinical experience, in pointing to purgatives, and not to opiates, as the right drugs to be given in peritonitis.

Serum Treatment.

The serum treatment of the septic diseases being in its infancy, and, so far, having shown only sporadic promise of the utility to which it may eventually attain, the little that we are able to say of its application to peritonitis can only take the form of speculation. We have endeavoured to show that, in the large majority of cases of acute peritonitis, it is the colon bacillus which kills the patient. At any rate, it is possible to ascertain, in a given case, whether this is so, very rapidly, by means of cover-slip preparations, and even of cultures taken at the operation. We believe that, did we possess a multivalent ant-coli serum, the mortality of peritonitis would speedily diminish. At present we know of no such serum, and we can only say here, that experiments are in progress with a view to producing a multivalent serum against the various virulent strains of the colon bacillus which have been isolated from our cases of peritonitis.

If films of the exudate were to show streptococci, we might reasonably hope that one of the more recently produced multivalent anti-streptococcic sera would prove of value. But the indiscriminate use of antitoxic sera in peritonitis, without regard to the bacteriology of the individual case, is as useless as it is unscientific.

At least, we have said enough to show that any hope based upon antitoxic sera must lie in the direction of a colon bacillus rather than upon a streptococcic antitoxin.

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TABLE I.

Case	Length of History	Pyrexia before Operation	Observations at time of Operation	Operation
21	14 days	100·2°	Large amount of recent and old clot free in peritoneal cavity. No smell. Right tube ruptured	Removal. Lavage Closure
41	3 weeks	101·2°	Large amount of recent blood, as well as older dark clot free in peritoneal cavity. No smell	Removal. Drainage
1A	3 weeks	99–101° for a week	Recent blood as well as dark, older blood and clot	Removal. Lavage. Drainage per vaginam
17A	24 hours	Not known	Large amount of dark blood and clot, the most recent being, as usual, first encountered	Removal. Lavage. Closure
33A	8 days	99–101°	About 3 pints of dark blood and clot with slight smell	Ditto
35A	3 months	One rise to 102°	Very little bloody fluid in peritoneal cavity. Encysted haemotocele, with dark blood, clot, and fibrin	Ditto
54A	24 hours	100·2°	Large amount of recent and old blood and clot. Tubal abortion. No smell	Ditto
56A	2 months	100° for 3 days	Small amount of bloody fluid free in peritoneal cavity. Dark blood and clot from leakage round end of pregnant tube. No smell	Ditto
70A	16 days	100·6°	Small amount of free blood in peritoneal cavity, and haematocele in pelvis. No rupture. Leakage. No smell	Ditto
84A	3 months	99–101° for several days	Bloodstained fluid in peritoneal cavity and haematocele in pelvis. No smell	Ditto
95A	3 weeks	98–101° for 9 days	Slightly bloody fluid in peritoneal cavity. Encysted haematocele round tubal abortion. No smell	Removal. Local Lavage. Appendicectomy. Closure
24B	6 weeks	Not known	Large amount of free blood and clot, the most recent being first encountered. No smell	Removal. Lavage. Closure
52B	5 weeks	98–100° for 8 days	Large amount of dark blood and clot free in peritoneal cavity. No smell	Ditto
70B	2 months	101°	Recent blood free in peritoneal cavity. Older blood and clot in pelvis. No smell	Ditto
83B	6 days	100°	Large amount of old and recent clot. Ruptured right tube	Ditto
84B	1 month	100° for 4 days	Ruptured left tube. Haematocele shut off from general cavity	Ditto
90B	1 month	None	Ruptured left tube. Old clot and blood in pelvis. More recent blood in general cavity	Ditto

Microscopic Examination	Bacteriological Examination		Pyrexia after Operation	Mode of Healing of Wound	Result
	Culture No. 1	Culture No. 2			
—	—	Staphylococcus albus	—	—	D.
—	Staphylococcus albus	Ditto	—	—	D.
—	Ditto	Ditto	99–103° for 9 days	Primary union	C.
Blood only. No micro-organisms	Sterile	Ditto	None	Ditto	C.
Ditto	Ditto	Gram-staining staphylococcus	99–103° for 13 days	Suppuration of abdominal wound	C.
Blood. Gram-staining cocci	Ditto	Staphylococcus albus	99–101° for 8 days	Suppuration	C.
Blood. No micro-organisms	Ditto	Ditto	99–100° for 2 days	Primary union	C.
Ditto	Ditto	Ditto	About 99° for a week	Ditto	C.
Ditto	Ditto	Ditto	Irregular for 3 weeks	Suppuration Pus: pure culture of Staphylococcus albus	C.
Blood. Gram-staining cocci and diplococci	Staphylococcus albus	Ditto	99–100° for several days	Primary union Late suppuration	C.
Blood. No micro-organisms	Sterile No. 3 Anaerobic: Staphylococcus albus	Ditto	About 100° for 4 days. A fortnight later purulent collection drained per vaginam	Primary union	C.
Ditto	Sterile	Staphylococcus albus	99–100° for 4 days	Ditto	C.
Ditto	Ditto	Ditto	10 days, gradually subsiding from 101°	Ditto	C.
Ditto	Ditto No. 3 Anaerobic: Sterile	Ditto	Slight for a few days	Ditto	C.
Ditto	Ditto No. 3 Anaerobic: Sterile	Ditto	Slight for 5 days	Ditto	C.
Blood. Gram-staining diplococci	Ditto	Ditto	About 100° for 6 days	Ditto	C.
Blood. No organisms	Staphylococcus albus	Ditto Anaerobic: Staphylococcus albus	Slight	Ditto	C.

TABLE II. TRAUMATIC

Case	Age and Sex	Causation	History	Observations at Operation
92A	M 7	Ruptured liver	5½ hours	Normal looking intestine and omentum on opening peritoneal cavity. Dark blood over right kidney. Rupture of liver at portal fissure. Also blood round spleen and in pelvis
51B	M. 9	Ruptured spleen	5 hours	Dark blood escaped on opening peritoneal cavity. Dark blood in flanks. Intestines reddened. No distension
53B	M. 10	Ruptured spleen	2 hours	Large amount of recent blood. Some darker blood also. Intestines reddened. No distension

Microscopical Examination	Bacteriological Examination	Operation and Result
Blood. No micro-organisms	1. Recent blood : Sterile 2. Dark blood } Staphylococcus albus 3. Ditto anaerobic } Staphylococcus albus	Rent plugged. Lavage. Death 36 hours later
No micro-organisms. Large numbers of cells (see text)	1. Recent blood : Sterile 2. Dark blood : Staphylococcus albus. Anaerobic culture : Sterile	Splenectomy. Lavage. C. Wound healed per primum.
Large numbers of all types of leucocytes (see text)	1. Recent blood : Sterile 2. Darker blood : Sterile	Splenectomy. Lavage. Death in a few hours. P.M. Liver also torn. No peritonitis

Table III.

Case	Age	History of Acute Symptoms	Pulse and Temperature	Condition found at Operation	Peritoneal Exudate
30B	33	5 days	120. 101°	Peritoneum reddened everywhere. Abscess suppurating ovarian cyst, and pyosalpinx more or less shut off from general cavity	1. Odourless turbid fluid. 2. Offensive pus
39B	33	7 days after previous operation	100–101° P. 80–100	Right pyosalpinx	—
63B	32	15 days	72. 98°	Redness of intestines. Double pyosalpinx	Clear fluid
3B	33	10 days	98–100°	Double pyosalpinx	—
68A	25	3 days	102·4°	Local peritonitis around double pyosalpinx (acute)	Blood-stained fluid in pelvis
89B	30	2 days	120. 102°	Adherent left pyosalpinx. Sac containing blood clot in situation of ovary. Slight redness of intestines	Sticky turbid yellowish fluid
11A	39	3 months	132. 100°	Large abscess connected with left pyosalpinx	Pus (localised)
12A	32	Few hours	—	Abscess connected with pyosalpinx burst into general peritoneal cavity. Commencing peritonitis	Large amount of odourless fluid

Note.—In this and the following tables, "P

SALPINGITIS

Operation	Microscopical Examination	Bacteriological Examination	Result
Removal, Lavage. Drainage	1. Peritoneal exudate. 2. Interior of cyst. 3. Interior of tube. P.N. and large mononuclear cells. Large numbers of diplococci chiefly intracellular, gram-negative 1, 2 and 3 similar	1. 2. 3. (Anaerobic) } Sterile	R. See next case
Removal. Drainage.	Peritoneal exudate. P.N. mostly degenerated. Diplococci in short chains extracellular. Stain by gram	1. 2. } Sterile.	C
Removal. Lavage. Drainage.	1. Interior of tube. P.N. No organisms. 2. Clear fluid. Few P.N. and large mononuclear cells. No micro-organisms	1. 2. } Sterile	C.
Removal. Drainage	Interior of tube. Many P.N. Some gram-negative bacilli	1. 2. } Sterile	C.
Ditto	Peritoneal exudate. No micro-organisms	1. Sterile 2. Fluid: A staphylococcus 3. (Interior) sterile	C
Removal. Lavage. Closure	1. Peritoneal exudate. P.N. One pair of diplococci gram-positive	1. Sterile 2. (Anaerobic) Sterile	C.
Incision. Drainage	No micro-organisms	Staphylococcus albus	C.
Removal. Lavage. Drainage	Peritoneal exudate. P.N. gram-negative bacilli gram-positive cocci	Bacilli which died out in both aerobic and anaerobic cultures	C.

N.” stands for polymorphonuclear neutrophils

TABLE IV.

Case	Age	History of Acute Symptoms	Pulse and Temperature	Condition found at Operation	Peritoneal Exudate	Operation
59B	35	4 weeks subacute 2 days acute	120. 100°	Cyst adherent. One cyst contained mucoid fluid; the other thick greenish offensive pus	Offensive seropurulent fluid and gas	Removal. Lavage. Drainage
73	30	7 days	120. 101–103°	No signs of peritonitis. Large tubo-ovarian abscess (left). Right pyosalpinx	1. Clear odourless fluid. 2. Thin offensive pus	Removal. Drainage
22A	30	3 days	120. 100°	Red and distended intestines. Dirty yellow fibrin. Gangrenous perforated ovarian cyst	Offensive purulent fluid	Removal. Lavage. Drainage

OVARIAN CYSTITIS

Microscopical Examination	Bacteriological Examination	Result
1. Peritoneal fluid. Numerous degenerated cells. No organisms 2. Mucoid fluid. Numerous P.N. No organisms. 3. Interior of suppurating cyst. Numerous P.N. Bacilli, not gram. Cocci, not gram	1. Peritoneal fluid: Staphylococcus albus 2. Ditto (anaerobic): B. coli. 3. Mucoid fluid: B. coli. 4. Pus: B. coli	D. third day. P.M. "General" peritonitis
1. No organisms. 2. P.N. Bacilli (not gram)	1. Sterile. 2. B. coli	D. second day. P. M. ditto
1. Cocci, staphylococci and streptococci (gram). Coccus (not gram)	1. Streptococcus pyogenes (surface of cyst). 2. Staphylococcus albus (surface of intestine)	D. same night. P.M. ditto

TABLE V.

Case	Length of History	Previous Taxis	Situation of Hernia	Sex and Age	Contents of Sac	Character of Exudate
7	48 hours	Yes	Femoral	F. 74	Deeply congested small gut and omentum	Clear fluid
15	4 days	—	Femoral	F. 78	Black, shiny partial enterocele	Brown fluid
25	3 days	Yes	Inguinal	M. 76	Deeply congested colon with gangrenous patch	Offensive pus
28	6 days	Yes	Femoral	M. 54	Dark partial enterocele with gangrenous patch	Sweet brown fluid
33	36 hours	—	Inguinal	M. 60	Congested small gut	Clear fluid
34	8 hours	Yes	Ditto	M. 42	Very congested partial enterocele. Haemorrhage into wall	Brownish fluid
35	15 hours	No	Ditto	M. 41	Slightly congested small gut	Straw-coloured fluid
36	5 hours	No	Ditto	M. 52	Deeply congested small gut with haemorrhage into lumen	Clear fluid
37	24 hours	Yes	Ditto	M. 3	Dark small gut with perforated gangrenous patch	Thin, non-smelling purulent fluid
43	7 days	Yes	Femoral	F. 66	Necrotic omentum and purple small gut	Yellowish fluid
46	48 hours	Yes	Inguinal	F. 1	Plum-coloured small gut	Straw-colour-fluid
48	5 days	Yes	Femoral	F. 45	Necrotic omentum and knuckle of very darkly congested small gut	Clear fluid
54	36 hours	Yes	Ditto	F. 40	Deeply congested small gut with subperitoneal haemorrhages	Slightly turbid fluid
70	16 hours	No	Inguinal	M. 30	Plum-coloured small gut with subperitoneal haemorrhages	Slightly blood-stained
81	3 days	No	Femoral	M. 60	Dark omentum and deeply congested small gut	Clear fluid
83	3 days	Yes	Ditto	F. 43	Necrotic omentum and black small gut	Blood-stained fluid
84	24 hours	Yes	Inguinal	M. $\frac{3}{12}$	Very slightly congested, small gut	Practically none
86	5 days	No	Umbilical	F. 53	Congested colon and omentum of good colour. Subperitoneal haemorrhages	Clear fluid, very little
87	12 hours	Yes	Inguinal	M. 43	Deeply congested small gut and haemorrhages	Clear fluid

STRANGULATED HERNIA

Operation	Microscopic Examination	Bacteriological Examination		Healing of Wound	Result
		Culture No. 1	Culture No. 2		
Herniotomy	—	Sterile	Sterile	Primary	C.
Ditto	—	Ditto	Ditto	Suppuration	C.
Ditto	—	Staphylococcus albus and bacillus coli	—	Ditto	C.
Sequestration and drainage	—	Sterile	—	Primary	C.
Radical cure	—	Ditto	Sterile	Ditto	C.
Ditto	—	Ditto	Ditto	Ditto	C.
Ditto	—	Ditto	Ditto	Ditto	C.
Ditto	—	Ditto	Ditto	Ditto	C.
Sequestration and drainage	—	Bacillus coli	Bacillus coli	By granulation	C.
Herniotomy and omentum excised	—	Ditto	Ditto	—	D. (P.M. Peritonitis)
Radical cure	—	Sterile	Sterile	Primary union	C.
Omentum excised and herniotomy	No micro-organisms. Endothelial cells only	Ditto	Staphylococcus albus	Ditto	C.
Herniotomy	No organisms	Ditto	Sterile	Ditto	C.
Radical cure	Ditto	Ditto	Ditto	Ditto	C.
Omentum excised and wound closed	Ditto	Ditto	Ditto	Ditto	C.
Ditto	Gram-staining cocci. Endothelial cells	Ditto	Staphylococcus albus	Ditto	C.
Radical cure	—	Ditto	Sterile	—	D. (erysipelas)
Omentum excised and wound closed	No organisms	Ditto	Staphylococcus albus	Primary	C.
		3. Staphylo	coccus albus		
Radical cure	Ditto	Ditto	Sterile	Ditto	C.
		3. St	erile		

TABLE V.

Case	Length of History	Previous Taxis	Situation of Hernia	Sex and Age	Contents of Sac	Character of Exudate
89	30 hours	No	Femoral	F. 68	Necrotic omentum and deeply congested small gut	Slightly brownish fluid
93	17 hours	Yes	Inguinal	M. 30	Plum-coloured small gut with much haemorrhage into wall and mesentery	Blood-stained fluid
94	5 days	Yes	Ditto	M. 45	Congested adherent small gut	Slightly blood stained
98	36 hours	No	Ditto	M. 17	Deeply congested small gut with necrotic greyish patches	Straw-coloured fluid
99	10 hours	Yes	Ditto	M. 17	Congested small gut	Ditto
6A	48 hours	Yes	Femoral	M. 69	Deeply congested partial enterocele with subperitoneal haemorrhages. Greyish patch at apex	bloodstaine fluid
8A	24 hours	Yes	Umbilical	F. 57	Brownish omentum and deeply congested small gut	Ditto
9A	6 hours	Yes	Inguinal	M 15	Slightly congested small gut	Practically none
15A	6 hours	Yes	Ditto	M. 40	Brownish omentum and deepy congested small gut	Clear fluid
16A	3 hours	No	Ditto	M. 40	Slightly congested small gut	Ditto
28A	36 hours	Yes	Ditto	M. $\frac{4}{12}$	Ditto	Practically none
31A	6 hours	Yes	Ditto	M. 32	Plum-coloured small gut	Straw coloured fluid
38A	50 hours	Yes	Femoral	F. 6	Gangrenous small gut	Bloody stinking fluid
45A	7 days	—	Umbilical	F 49	Necrotic omentum and deeply congested colon	None
46A	30 hours	Yes	Femoral	F. 49	Black small gut	Brownish fluid with no smell

STRANGULATED HERNIA (*continued*)

Operation	Microscopic Examination	Bacteriological Examination		Healing of Wound	Result
		Culture No. 1	Culture No. 2		
Omentum excised and wound closed	No organisms	Sterile	Staphylococcus albus	Primary	C.
Herniotomy and drainage	Ditto	Ditto	Sterile	— within 24 hours (P.M. No peritonitis)	D.
Herniotomy	Ditto	Ditto	Ditto	— suddenly. (P.M. Diffuse peritonitis: no gangrene or perforation.	D.
Resection and drainage	—	Ditto	Staphylococcus albus 3. Staphylococcus albus	— Of obstruction and peritonitis	D.
Radical cure	No organisms	Sterile	Staphylococcus cereus albus	Primary union	C.
Herniotomy	Ditto	Ditto	Staphylococcus albus	Ditto	C.
Omentum excised and radical cure	Ditto	Ditto	Ditto	Ditto	C.
Radical cure	Ditto	Ditto	Sterile	Ditto	C.
Omentum excised and radical cure	Ditto	Ditto	Ditto	Ditto	C.
Radical cure	Ditto	Ditto	Ditto	Ditto	C.
Ditto	Ditto	Ditto	Ditto	Ditto	C.
Ditto	Ditto	Ditto (anaerobic)	Ditto	Ditto	C.
Resection and anastomosis	Pus corpuscles containing non-gram staining bacilli. Extra cellular bacilli which do not stain by gram and gram staining cocci	Bacillus coli	Bacillus coli	— (P.M. Pulmonary embolism)	D.
Omentum excised and radical cure	No organisms	Sterile	Sterile	— (P.M. No peritonitis; gut "looked bad."	D.
Herniotomy	Ditto Large numbers of P.N.	Ditto	Ditto	Primary union	C.

TABLE V.

Case	Length of History	Previous Taxis	Situation of Hernia	Sex and Age	Contents of Sac	Character of Exudate
48A	5 days	No	Ventral	M. 52	Brownish omentum and congested stomach	Clear fluid
61A	48 hours	Yes	Femoral	F. 63	Congested small gut	Straw-coloured fluid
73A	6 hours	Yes	Inguinal	M. $\frac{4}{12}$	Ditto	Clear fluid
91A	12 hours	Yes	Ditto	M. $\frac{1}{12}$	Slightly congested small gut	Ditto
99A	12 hours	Yes	Ditto	M. 65	Slightly congested but very oedematous small gut	Ditto
100A	32 hours	Yes	Ditto	M. 40	Congested small gut	Ditto
13B	24 hours	—	Ditto	M. 42	Ditto	Bloodstained fluid
14B	6 hours	Yes	Ditto	M. 38	Deeply congested small gut with subperitoneal haemorrhages	Straw-coloured fluid
16B	3 days	Yes	Umbilical	F. 48	Deep red small gut and congested omentum	Very small amount of sticky exudate
18B	2 days	Yes	Inguinal	M. $\frac{6}{12}$	Congested small gut	Bloodstained fluid
19B	8 hours	Yes	Ditto	M. $\frac{6}{12}$	Congested caecum and appendix	Straw-coloured fluid
20B	4 days	Yes	Femoral	F. 64	Necrotic omentum and deeply congested small gut with haemorrhages	Bloodstaine fluid
35B	3 days	Yes	Ditto	F. 58	Plum-coloured small gut and necrotic omentum	Brownish odourless fluid

STRANGULATED HERNIA (*continued*)

Operation	Microscopic Examination	Bacteriological Examination		Healing of Wound	Result
		Culture No. 1	Culture No. 2		
Omentum excised and radical cure	No organisms	Sterile	Staphylococcus albus	Primary	C.
Herniotomy	Ditto	Ditto	Sterile	Suppuration	C.
Radical cure	Ditto	Ditto	Ditto	Primary	C.
Ditto	Ditto. No cells	Bacillus coli and a gram-staining staphylococcus	Bacillus coli and a staphylococcus staining by gram	Suppuration	C.
Ditto	No organisms Endothelial cells and P.N.	Sterile (anaerobic)	Sterile	Primary	C.
Ditto	Ditto	Ditto	Ditto	Suppuration	C.
Ditto	No organisms. Blood	Ditto	Ditto	Primary	C.
Ditto	Ditto. Endothelial cells	Sterile	Ditto (anaerobic)	Ditto	C.
Omentum excised and radical cure	No organisms. Large numbers of P.N. and endothelial cells	Ditto	Ditto	Ditto	C.
Radical cure	—	Ditto	—	Ditto	C.
Ditto	Large numbers of endothelial cells : no organisms	Ditto	Staphylococcus albus	Ditto	C.
Omentum excised and radical cure	No organisms. Endothelial cells and P.N.	Ditto 3. Sterile	Sterile (anaerobic)	Ditto	C.
Omentum excised and radical cure	No organisms. Endothelial cells	Ditto 3. Staphylococcus albus (anaerobic)	Staphylococcus albus	Suppuration	C.

TABLE VI.

Case Sex and Age	Cause	Length of History	Condition of Bowel	Character of Exudate	Operation
2. F. $\frac{3}{12}$	Intussusception	17 hours	Deeply congested	Clear fluid	Reduction
3. M. 9	Ditto	48 hours	Congested and oedematous	Ditto	Ditto
6. M. $\frac{5}{12}$	Ditto	60 hours	Extreme congestion	Ditto	Ditto
14. M. 7 weeks	Ditto	31 hours	Black and oedematous	Straw-colour-fluid	Ditto
53. M. $\frac{10}{12}$	Ditto	24 hours	Congested and oedematous	Clear fluid	Ditto
57. M. $\frac{5}{12}$	Ditto	10 hours	Slight congestion	Very little clear fluid	Ditto
65. M. $\frac{8}{12}$	Ditto	7 hours	Ditto	No fluid	Ditto
4A. F. $\frac{6}{12}$	Ditto	2 days	Very slight congestion	Very little clear fluid	Ditto
25A. F. 22	Ditto	2 days	Gangrenous	Clear fluid.	Resection and axial anastomosis
51A. M. $1\frac{11}{12}$	Ditto	38 hours	Plum-coloured and oedematous	Straw-coloured fluid	Reduction
57A. M. $\frac{6}{12}$	Ditto	18 hours	Deep congestion	Clear fluid	Ditto
58A. M. $\frac{4}{12}$	Ditto	2 days	Deep congestion of oedema. Subperitoneal haemorrhage	Very little clear fluid	Reduction and appendicectomy
86A. M. $\frac{8}{12}$	Ditto	7 days	Gangrenous	Bloodstained fluid	Resection and enterostomy
27B. F. $\frac{7}{12}$	Ditto	24 hours	Plum-coloured and oedematous	No fluid	Reduction
17. M. 59	Carcinoma of sigmoid	10 days	Great distension and moderate congestion	Clear fluid in fair quantity	Colostomy
51. F. 69	Carcinoma of caecum	4 days	Red and distended	Small amount of clear fluid	Ileostomy
58. F. 33	Carcinoma of colon	24 hours	Ditto	No fluid	Colostomy
20A. M. 50	Carcinoma of sigmoid	Weeks	No distension	Large amount of straw-coloured fluid	Ditto
21A. F. 63	Carcinoma of rectum	Days	Red and distended. No fibrin	Small amount of clear fluid	Ditto
27A. F. 50	Carcinoma of sigmoid	Days	Much distension and redness	Very little clear fluid	Ditto

INTESTINAL OBSTRUCTION.

Microscopic Examination	Bacteriological Examination		Healing of Wound	Result
	Culture No. 1	Culture No. 2		
—	—	Staphylococcus albus	Suppuration	C.
—	Sterile	Ditto	Ditto	C.
—	Ditto	Sterile	Ditto P. M. Perforation	D. Peritonitis
—	Staphylococcus albus	Staphylococcus albus	Primary	C.
No organisms. Endothelial cells	Sterile	Ditto	Ditto	C.
Ditto	Ditto	Sterile	Ditto	C.
Ditto	Staphylococcus albus	Staphylococcus albus	Ditto	C.
Ditto	Sterile	Ditto	Ditto	C.
Ditto	Ditto 3. Staphylococcus albus	Ditto	Suppuration	C.
Ditto	Staphylococcus albus	Staphylococcus albus	Primary	C.
Ditto	Sterile	Sterile	Ditto	C.
Ditto	Ditto	Staphylococcus albus	— On 3rd day. Peritonitis	D. P.M. No
No organisms. Endothelial cells and blood	Staphylococcus albus. Bacillus coli and proteus vulgaris	Staphylococcus albus. Bacillus coli and proteus vulgaris	— Almost immediately	D.
No organisms. Endothelial cells	Sterile 3. Anaerobic culture. Staphylococcus albus	Staphylococcus albus	— On 3rd day. P.M. Peritonitis	D. Plastic
—	Sterile	Staphylococcus albus	—	R.
—	Ditto	Sterile	— 5th day. P.M. Peritonitis & metastatic growth	D.
—	—	Ditto	—	R.
No micro-organisms	—	Ditto	— P.M. No Peritonitis	D.
P.N. and mononuclear cells. Bacilli and cocci in cells	Sterile	Ditto	—	R.
No micro-organisms	Staphylococcus albus	Bacillus coli and staphylococcus albus	— 8th day of Peritonitis	D.

TABLE VI.

Case Sex and Age	Cause	Length of History	Condition of Bowel	Character of Exudate	Operation
37A. F. 54	Carcinoma of rectum	Chronic	Reddened	Very little clear fluid	Colostomy
42A F. 42	Carcinoma of sigmoid	10 days	Reddened and distended	Clear fluid	Exploration
44A F. 71	Carcinoma of ileum	10 days	Great distension	Ditto	Ileostomy
50A. M. 74	Carcinoma of colon	6 days	Great distension and thinning. Reddened	Ditto	Colostomy
9B. F. 73	Carcinoma of hepatic flexure	7 days	Great distension and redness. Peritoneum split over colon	—	Ditto
34B. F. 56	Carcinoma of transverse colon	10 days	Distended, thinned and reddened	Clear fluid	Resection and colostomy
62B. F. 49	Carcinoma of sigmoid	7 days	Distension	Clear fluid in small amount	Colostomy
73B. F. 75	Carcinoma of hepatic flexure	14 days	Old adhesions. Redness and distension	Clear fluid	Ditto
47. F. 52	Impaction of gall-stone in ileum	5 days	Congested	Ditto	Enterootomy and removal
13. F. 72	Ditto	3 days	Distension	Clear fluid in small amount	Ditto
88A. F. 53	Ditto	27 hours	Slight distension and redness	Clear fluid	Ditto
44. F. 67	Volvulus of caecum	6 days	Enormous distension and thinning. Reddened	Ditto	Reduction
39. M. 26.	Adhesions	11 days	Redness. Many vascular adhesions	None	Enterolysis
62. M. 16	Ditto	5 days	Redness and distension. Vascular adhesions about appendix	Ditto	Ditto
72. F. 50	Meckel's diverticulum	5 days	Red, deeply congested and soft. Ulcerated constriction ring	Straw-coloured fluid	Resection and anastomosis
79. F. 11	Adhesions to a caseous mesenteric gland	5 days	Reddened. Not much distension	Clear fluid	Enterolysis
85. M. 14	Ditto	24 hours	Reddened and distended	Small amount of clear fluid	Ditto
91. M. 66	Adhesions	1 week	Distended. Gangrene of coil of small intestine	Brownish fluid. No smell	Enterostomy
5A. M. 15	Ditto	3 days	Distension	Small amount of clear fluid	Enterolysis

INTESTINAL OBSTRUCTION (*continued*)

Microscopic Examination	Bacteriological Examination		Healing of Wound	Result
	Culture No. 1	Culture No. 2		
Gram-staining diplococci	Staphylococcus albus	—		R
Large mononuclear cells. Gram-staining diplococci	Ditto	—	—	R.
No organisms	Sterile	Sterile	—	D. 3 weeks later. Exhaustion
Ditto	Ditto	Staphylococcus albus	—	D. 3 days later
Mononuclear cells and a few P.N. No organisms	Ditto	Sterile (anaerobic)	—	R.
Ditto	Ditto	Ditto	—	D.
Ditto	Ditto	Sterile	—	R.
Ditto	Ditto	Ditto	—	R.
—	Ditto	Ditto	—	D. "General" Peritonitis
—	Ditto	—	—	D. From Uraemia
No organisms. Mononuclear cells	Ditto	Staphylococcus albus	—	C.
Ditto	Ditto	Ditto	Suppuration	C.
Ditto	Ditto	Ditto	—	D. 13th day
—	Ditto	Sterile	Suppuration	C.
—	Ditto	Ditto	Ditto	C.
Mononuclear cells. No organisms	Ditto	Staphylococcus albus	Primary	C.
—	Ditto	Ditto	Suppuration	C.
No organisms	Ditto	Bacillus coli and a gram-staining staphylococcus which died out	—	D. In a few hours
—	Ditto	Sarcina lutea	—	D. 3rd day. P.M. Peritonitis

TABLE VI.

Case Sex and Age	Cause	Length of History	Condition of Bowel	Character of Exudate	Operation
52A. F. 49	Adhesions	5 days	Much matting	Straw-coloured fluid	Enterolysis
76A. M. 27	Ditto	3 days	Red and distended	Clear fluid	Ditto
15B. M. 6	Ditto	3 days	Ditto	Ditto	Ditto
17B. F. 32	Ditto	4 days	Ditto	Straw-coloured fluid	Ditto
26B. M. 8	Meckel's diverticulum	3 days	Moderate distension and redness	Ditto	Ditto
3A. M. 17	Kinking after anastomosis	2 days	Red and distended. Small amount of lymph round anastomosis. No obvious peritonitis	Large amount of thin turbid fluid	Lateral anastomosis
23A. M. 15	Strangulated internal hernia	4 days	Plum-coloured. Necrotic patches. No perforation. Loss of polish	Bloodstained non-smelling fluid	Resection and enterostomy
61. M. 54	Cicatricial stricture of sigmoid	3 days	Distension	—	Colostomy
13A. F. 27	Intestinal neurosis	4 days obstructive symptoms	Distension	None	Exploration
7A. M. 5	Congenital dilatation of colon	6 days	Enormous distension and thickening	Ditto	Ditto
29B. M. 1	Ditto	7 days	Ditto	A little clear fluid	Intestine tapped
34A. M. 2days	Imperforate anus	2 days	Enormous distension. Very thin bowel wall	Large amount of clear fluid	Perineal colostomy
95. F. 30	Kinking after gastro enterostomy	2 days	Red and sticky. Some lymph round anastomosis	No fluid	Lateral anastomosis
72A. F. 38	Strangulation by stitch after hysterectomy	3 days	Thinned and fairly deeply injected gut with flakes of fibrin	Clear fluid	Enterolysis

Microscopic Examination	Bacteriological Examination		Healing of Wound	Result
	Culture No. 1	Culture No. 2		
Intracellular gram-staining diplococci. P.N.	Sterile	Sterile	—	D. Same day
No organisms	Ditto	Ditto	—	C.
Mononuclear cells and P.N. No organisms	Ditto	Ditto	—	D. In 48 hours (diphtheria)
No cells or organisms	Ditto	Ditto	Primary	C.
Large mononuclear cells. No organisms	Ditto	Ditto	Ditto	C.
No organisms. P.N.	Bacillus coli In both gram-staining staphylococci, not isolated	Bacillus coli	—	D. 2nd day
P.N. Non-gram bacilli	Sterile	(Aerobic and anaerobic) Bacillus coli	—	D. In a few hours
No organisms	Ditto	Sterile	—	D. 2nd day
Large mononuclear cells. Gram-staining cocci	—	Staphylococcus albus	Primary	C.
—	Sterile	Ditto	Ditto	C.
No organisms. P.N. and mononuclear cells	Ditto	Sterile	—	D. next day
No organisms. P.N.	Ditto 3. (Meconium)	Bacillus coli bacillus coli	—	D. 3rd day P.M. No peritonitis
—	Staphylococcus albus	Staphylococcus albus	Primary	C.
P.N. and large mononuclear cells. No organisms	Staphylococcus aureus	Staphylococcus aureus	—	D. Same night

TABLE VII. INFLAMMATION

Case	Sex and Age	Length of History	Cause of Perforation	Pulse and Temperature	Observations at Operation	Character of Exudate
18A	M. 68	17 days	Perforation of gall bladder over a calculus	— 101°	Vascular adhesions about gall bladder. Necrotic material around perforation No actual pus seen Peritonitis localised	Very scanty fibrinous — —
91B	—	—	Empyema of gall-bladder —local peritonitis	—	Recent adhesions	No fluid in peritoneum. Thick white odourless pus in gall bladder
75B	M. 32	14 days	Chronic gastric ulcer. Perigastric abscess	— 101°	General peritoneal cavity not opened	About a drachm of thick white odourless pus
43B	F. 21	24 hours	Chronic gastric ulcer	130. 101°	Small perforation on anterior surface near pylorus practically closed by plastic lymph	Clear, slightly greenish, slightly viscid
97A	M. 32	6 hours	Ditto	120. 98°	Perforation on anterior wall close to pylorus	Milky fluid, large quantity and flakes of lymph
4B	F. 23	14 hours	Ditto	—	Perforation on anterior surface near cardiac end	Turbid fluid and free gas. Fibrin round the perforation
74A	F. 19	24 hours	Ditto	120. —	Intestines distended and reddened. Perforation on posterior wall near middle of lesser curvature	Large quantity of thin turbid fluid. Flakes of fibrin
59A	M. 27	32 hours	Ditto	108. 100°	Small perforation on anterior surface near pylorus	No gas. Much greenish turbid fluid
82	F. 25	19 hours	Ditto	Collapse	Large perforation on anterior surface near pylorus. Little redness or distension	Much turbid fluid and gas.
76	M. 57	28 hours	Ditto	100. —	Intestines reddened. Large perforation on anterior wall near pylorus	Gas and turbid greenish fluid.
22B	F. 23	25 days	Subphrenic abscess after operation for perforated gastric ulcer	— —	Local left-sided subphrenic abscess	Thick odourless cream-coloured pus

AND PERFORATION OF HOLLOW VISCERA

(*Re* Gastric Ulcer, *see also* Table IX.)

Microscopical Examination	Bacteriological Examinatiou	Operation	Result
P.N. No organisms (From tissues around gall-bladder)	1. Abdominal cavity : Sterile 2. Around gall-bladder : Pure culture of a streptococcus 3. Interior of gall-bladder : Same streptococcus	Drainage	C.
P.N. Bacilli (not gram)	1. Sterile (peritoneal cavity) 2. (Local peritonitis) sterile 3. (Anaerobic: interior) Bacillus coli	—	—
P.N. Cocci, diplococci and short chains (not gram)	Pure culture of a strepto-diplococcus	Drainage	
Gram-staining cocci. P.N.	1. Fluid : Strepto-diplococcus 2. Edge of ulcer : Strepto-diplococcus and staphylococcus albus 3. Anaerobic. Edge of ulcer : Ditto	Suture. Limited lavage. Closure Healed per	C. primam
P.N. No organisms	1. Fluid 2. Edge of ulcer 3. Ditto (anaerobic) } Strepto-diplococcus in pure culture	Suture. Lavage. Drainage	C.
P.N. Cocci, diplococci and streptococci (not gram)	1. Fluid 2. Edge of ulcer 3. Ditto (anaerobic) } Strepto-diplococcus	Ditto	C.
P.N. No organisms	1. Fluid : Strepto-diplococcus 2. Edge of ulcer 3. Ditto (anaerobic) } Bacillus coli and strepto-diplococcus	Ditto Same night. P.M. "G Peritonitis, very little Peritoneum everywher	D. eneral" fluid, e sticky
—	1. Fluid: Sterile 2. Edge of ulcer : Strepto-diplococcus	Ditto	—
P.N. Diplococci (gram)	1. Fluid : Sterile 2. Edge of ulcer : Staphylococcus albus and strepto-diplococcus 3. Surface of stomach : Ditto	Ditto 10 days later of pneu	D. septic monia
P.N. Cocci (gram)	1. Fluid : Sterile 2. Surface of intestine 3. Edge of ulcer } Staphylococcus albus and strepto-diplococcus	Suture. Lavage. Closure Healed per	C. primam
P.N. and endothelial cells. Large number of diplococci and short chains of diplococci (not gram)	1. Pleural sac 2. Abscess 3. Ditto (anaerobic) } Pure culture of strepto-diplococcus and staphylococcus albus	Drainage P.M. Portal	D. Pyaemia

TABLE VII. INFLAMMATION AND

Case	Sex and Age	Length of History	Cause of Perforation	Pulse and Temperature	Observations at Operation	Character of Exudate
50	M. 35	19 hours	Chronic duodenal ulcer	140. 97°	Perforation of anterior wall near pylorus	Much turbid sour-smelling fluid and gas
12	M. 40	9 hours	Ditto	120. 99°	Ditto	Free fluid
9	M. 35	4 hours	Ditto	— —	Ditto	Much turbid fluid and gas
10	M. 29	4 hours	Ditto	— —	Ditto	Free fluid and gas
50B	M. 30	4 hours	Perforation of peptic ulcer of jejunum after gastro-jejunostomy	120. —	Redness of peritoneum	Turbid, odourless fluid and gas
52	M. 18	20 hours	Gunshot wound of small intestine	120. N.	Two minute perforations and three bruises of bowel wall	Small amount of blood
64A	M. 8	6th week of disease 2 days perforation	Typhoid ulcer. Typhoid-serum reaction positive	— —	Diffuse peritonitis. Pin-point perforation 4″ from ileo-caecal valve. Another ulcer on the point of perforation	2–3 ounces of odourless turbid fluid. Gas
92B	M. 30	10 hours 3rd week of illness	Perforated typhoid ulcer. Serum reaction negative	116. 99°	Two minute perforations close to ileo-caecal valve	Two pints of yellowish milky fluid in lower part of abdomen. Much free gas
82A	F. 60	5 days	Perforated carcinoma of colon—local abscess	— 102°	Intestines red but not distended—loculus of clear fluid near tumour—then abscess with offensive smell around growth	1. Clear fluid 2. Foul pus
81B	M. 20	36 hours	Perforated chronic ulcer of ileum	120. 100°	Large perforation in ileum close to caecum. Intestines red and distended. Much fibrin	Clear odourless fluid in peritoneal cavity

Microscopical Examination	Bacteriological Examination	Operation	Result
P.N. Non-gram bacilli	1. Fluid 2. Surface of duodenum } Bacillus coli 3. Edge of ulcer: Bacillus coli and strepto-diplococcus (isolated but not fully worked out)	Suture. Lavage.	D. In a few hours. P.M. Diffuse Peritonitis
—	1. Fluid: Sterile 2. Gut surface: Staphylococcus albus	Ditto	C.
—	1. Fluid: Sterile 2. Edge of ulcer: Staphylococcus albus	Suture. Lavage. Drainage	C.
—	1. Fluid: Sterile 2. Edge of ulcer: Staphylococcus albus	Ditto	D. From Pneumonia on 3rd day
Large numbers of degenerated cells. Few P.N. No organisms	1. Fluid 2. Surface of gut } Staphylococcus albus 3. Edge of ulcer	Ditto	C.
Blood only. No organisms	1. Sterile (peritoneal surface) 2. Blood: Staphylococcus albus	Suture. Lavage. Closure	C. Wound per primam
P.N. Non-gram bacilli	Fluid (aerobic and anaerobic): Staphylococcus aureus and bacillus coli	Suture. Drainage	D. In a few hours
P.N. Diplococci (gram). Bacilli (not gram) intracellular	Aerobic and anaerobic cultures of exudate: Three strains of bacillus coli. Staphylococci (gram)	Suture. Lavage. Closure	D. In 48 hours. P.M. Universal Peritonitis and a third perforation
1. P.N. No organisms 2. P.N. Gram-staining cocci. Bacilli (not gram)	1. Surface of omentum: Sterile 2. Surface of intestine: Staphylococcus albus 3. Clear fluid: Staphylococcus albus 4. Pus. Staphylococcus albus and Bacillus coli	Drainage	D. 4 hours later. P.M. Intense universal Peritonitis
P.N. No organisms	1. Aerobic Sterile 2. Anaerobic Pure culture of a minute coccus (see text)	Resection. Enterostomy. Lavage	D. On following day

TABLE VIIIA. ACUTE APPENDICITIS WITH

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Appearance of Intestines	Operation
			A. At a Distance	B. Immediately round Appendix		
5 M. 31	24 hours	124. 101°	Turbid non-smelling fluid	Turbid non-smelling fluid	Moderate degree of redness and distension in right iliac fossa	Dry sponging and drainage
31 F. 17	48 hours	150. 97·6°	None	Lymph	Reddened and distended, most marked in lower segment	Irrigation and drainage
45 F. 10	3 days	120. 103°	Thin offensive fluid	Thick offensive pus	Necrotic appendix	Drainage
49 M. 13	3 days	120. 98°	Thin non-smelling turbid fluid	Thick pus	Red and distended	Removal, irrigation and drainage
59 F. 20	4 days	130. 102°	Thin offensive turbid fluid	Ditto	General redness of intestines without distension. Lymph about appendix Gangrenous non-perforated appendix	Removal, irrigation and closure
77 M. 16	4 days	88. 102°	Clear non-smelling fluid	Ditto	No adhesions. Appendix large, swollen and acutely inflamed. Gangrene in patches. No concretion	Removal, dry sponging
40A F. 3½	10 days	150. 100°	Turbid brownish fluid	Creamy pus	Intestines collapsed and only slightly reddened. Intensely inflamed round appendix. Appendix sloughy and contained large concretion	Removal. Lavage. Drainage

DIFFUSE NON-PERFORATIVE PERITONITIS.

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A	Of Exudate B	Of Exudate A	Of Exudate B	
—	—	—	Bacillus coli (2 cultures)	C.
—	—	Sterile	Sterile	D. 3rd day
—	P.N. Non-gram bacilli groups of gram - staining cocci	B. pyocyaneus and staphylococcus albus	B. pyocyaneus and staphylococcus albus	D. 2nd day P.M. Universal peritonitis
Large numbers of polymorphonuclear neutrophils. No organisms	Large numbers of P.N. Non-gram—staining bacilli	Sterile	Bacillus coli	D. 10th day P.M. Loculated universal peritonitis
Polymorphonuclear neutrophils. Non-gram bacilli. Cocci in groups. Staining by gram	Same as exudate A	Bacillus coli. Staphylococcus albus Staphylococcus aureus	Same as exudate A	D. on following day
Endothelial cells ; No	P.N. organisms	Sterile	2. Sterile 3. Staphylococcus albus (surface of appendix)	C. Suppuration
Large numbers of P.N. containing non-gram bacilli. Similar bacilli extracellular. No cocci seen	—	Bacillus coli	Bacillus coli	D. same night

TABLE VIIIA. ACUTE APPENDICITIS WITH

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Appearance of Intestines	Operation
			A. At a Distance	*B.* Immediately round Appendix		
69B M. 13	20 hours	100. 100°	None	Clear odourless fluid	No adhesions. Appendix thrombosed (early gangrene). Yellowish green lymph on surface. Wall thin	Removal, sponging, closure
82B F. 16	48 hours	124. 102°	Clear odourless fluid	—	Some distension and injection near appendix. Appendix thickened and kinked. No ulceration. Contained bloody mucoid fluid	Sponging and closure
74B F. 35	Previous abscess 11 weeks ago; worse few days	100. 100°	Sticky exudate and localised odourless abscess	Offensive pus	Reddened. No distension	Sponging, and drainage
93A F. 22	27 hours	130. 101·8°	None	Yellow lymph	No adhesions. No sign of peritonitis except over appendix itself	Local lavage and closure

DIFFUSE NON-PERFORATIVE PERITONITIS (*continued*)

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A.	Of Exudate B.	Of Exudate A	Of Exudate B.	
Enormous numbers of P.N. and mononuclear cells. No organisms	Similar to Exudate A. Films from interior. P.N. in large numbers. Bacilli (not gram). Groups of cocci (not gram)	Sterile (aerobic and anaerobic) Interior (aero bic) Bacillus	Sterile bic and anaero- coli	C. Primary union
P.N. mostly degenerated. No organisms	—	Bacillus coli Interior (aerobi bic) Bacillus Also groups of Not cul	Bacillus coli c and anaero- coli cocci (gram). tivated	D. 3rd day
No cells. No organisms	Few P.N. No organisms	Sterile Bacillus coli and albus. Aerobi Bacillus	Staphylococcus albus staphylococcus c and anaerobic coli	C. Primary union
—	P.N. in large numbers. No organisms	Sterile	Sterile (aerobic and anaerobic)	C. Primary union

TABLE VIIIB. ACUTE APPENDICITIS

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Appearance of Intestines	Operation
			A. At a distance	B. Immediately round Appendix		
1 F. 26	48 hours	112. 101·2°	Thin non-smelling fluid	Thick offensive pus	Intense inflammation and paralytic distension	General irrigation and drainage
19 M. 16	Some days	— —	Offensive pus	Ditto	Black, distended paralytic intestines	Ditto
20 M. 21	Several days	— —	Ditto	Ditto	Ditto	Ditto
74 M. 22	36 hours	100. 100·6°	—	Slightly turbid fluid and bubbles of gas	Reddened (no distension), more marked towards appendix	Ditto
26A M. 14	9 days. Worse few hours	132. 100·8°	Turbid odourless fluid	Thick offensive fluid pus	Reddened and distended. "Leaking abscess"	Ditto
49A M. 18	6 days	108. 98°	Fluid not so offensive	Dark offensive fluid and lymph	Distended and reddened. Appendix gangrenous. Peritonitis all over but most intense in right iliac region	Ditto
55A F. 13	Few days (indefinite)	Running pulse	Thin turbid offensive fluid	Ditto	Distended and intensely reddened intestines covered with flakes of lymph	Ditto
75A M. 7	50 hours	120. 101°	Fluid present	Offensive pus	General stickiness and redness	Limited lavage and drainage
80A M. 18	4 days	140. 100°	Non-smelling fluid somewhat blood-stained	Offensive pus	Appendix gangrenous. Concretion. Intestines deeply reddened and almost gangrenous. Much lymph	General irrigation and drainage
87A M. 1¼	48 hours	140. 100°	Non-smelling pus	Non-smelling pus	Reddened, not distended. More marked in right iliac region	Closure

WITH DIFFUSE PERFORATIVE PERITONITIS.

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A	Of Exudate B	Of Exudate A	Of Exudate B	
—	—	Bacillus coli	Bacillus coli	D. within 48 hours
—	—	Bacillus coli and sarcina lutea	Bacillus coli and sarcina lutea	D. in a few hours
—	—	Bacillus coli	Bacillus coli	D. in a few hours
—	P.N. Non-gram bacilli; groups of gram-staining cocci	—	Bacillus coli and a staphylococcus. Anaerobic ditto	C. Suppuration of Wound Bacillus Coli and a Staphylococcus
—	Ditto	Bacillus coli and staphylococcus albus	Bacillus coli and staphylococcus albus	C.
P.N. Gram-staining diplococci	Same cells. Bacilli not gram	Staphylococcus cereus albus	Aerobic and anaerobic: Bacillus coli	D. 3rd day
P.N. and non-gram bacilli	Ditto	Bacillus coli	Bacillus coli	D. same night
—	P.N. Gram-staining cocci. Non-gram-bacilli	Ditto	Aerobic and anaerobic: Bacillus coli	D. same night
P.N. No organisms	P.N. Cocci and short chains (gram). Bacilli (not gram). Pointed bacilli (gram)	Ditto *Blood culture:* basilic v	Aerobic and anaerobic: Bacillus coli 10 c.c. from ein. Sterile	D. in 24 hours
—	P.N. Groups of cocci (gram). Bacilli (not gram)	Bacillus coli	Bacillus coli	D. 7 hours later

TABLE VIIIB. ACUTE APPENDICITIS

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Appearance of Intestines	Operation
			A. At a distance	B. Immediately round Appendix		
96A F. 21	5 days	160. 99·6°	Clear fluid No smell	Thin odourless pus	General inflammation, most intense in right iliac region. Appendix gangrenous. Collection of thin non-smelling pus near spleen	General irrigation and drainage
8B F. 22	43 hours	130. 104°	No fluid	Turbid fluid	Injected, more marked round caecum. Gangrenous appendix	Dry sponging and closure
11B	4 days	140. 98°	Large quantity of pus everywhere		Appendix gangrenous. Concretion	General irrigation and drainage
28B M. 20	3 days	88. 100°	Turbid fluid	Offensive pus	Red and distended. Gangrene of appendix	General irrigation and drainage
54B F. 19	48 hours	130. 103°	Clear, yellowish, non-smelling fluid	Offensive pus	Red, no distension. Gangrene of appendix	Local dry sponging and drainage
56B F. 55	2 days	120. 98·4	Large amount of clear, odourless fluid	Offensive pus	Distended, reddened, thinned. Appendix rotten	General irrigation and closure
77B F. 54	7 days	130. 101°	Large amount of turbid odourless fluid	Offensive pus	Redness with distension ; increasing towards appendix and lymph	Sponging and drainage

WITH DIFFUSE PERFORATIVE PERITONITIS (*continued*)

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A	Of Exudate B	Of Exudate A	Of Exudate B	
P.N. Mononuclear cells. No organisms	P.N. Bacilli only (non-gram)	Sterile	Aerobic and anaerobic : Bacillus coli	D. 4th day
—	P.N. Bacilli (not gram). No cocci	Bacillus coli	Anaerobic and aerobic : Bacillus coli	C.
Very few and degen numbers of cocci, chains (gram). E bacilli (not gram) degenerated	erated cells. Large diplococci and short normous masses of many much	—	Anaerobic and aerobic : Bacillus coli	D. in a few hours
—	Cells degenerated beyond recognition. Diplococci (gram and not gram). Bacilli (not gram). Long thin bacilli (not gram)	Aerobic and anaerobic : Bacillus coli	Bacillus coli. Also diplococci (not gram) not isolated	D. in 8 hours
—	P.N. Bacilli (not gram). Long thin bacilli (not gram)	Two cultures : Bacillus coli	Aerobic and anaerobic : Bacillus coli. Also gram staining diplococcus not isolated	C.
P.N. No organisms	P.N. Mostly degenerated. Bacilli (not gram). Cocci and diplococci (gram). Short curved bacilli (not gram)	Two cultures : Bacillus pyocyaneus	Aerobic and anaerobic Bacillus pyocyaneus	D. in 36 hours
P.N. Diplococci and streptococci (not gram)	P.N. Bacilli (not gram). Cocci (gram)	1. Streptococcus pyogenes 2. Staphylococcus albus and streptococcus	Bacillus coli	D. in a few hours

TABLE VIIIc.

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Observations at Operation	Operation
			A. In general Cavity	B. Contents of Abscess		
18 M. 22	13 days	92. 100·4°	—	Thick offensive pus	—	Drainage
22 M. 13	9 days	— —	—	Thick offensive pus	—	Ditto
26 M. 20	14 days	88 101°	—	Ditto	—	Subsequent removal
27 M. 33	4 days	88. 101·2°	—	Thin offensive pus	—	Drainage.
29 M. 16	10 days	132. 98·6°	No fluid or lymph	Thin offensive pus	Intestines reddened and rather distended	Ditto
30 M. 15	8 days	116. 103°	—	Offensive pus	—	Ditto
32 M. 12	3 days	142. 100·4°	—	Thin foul pus	—	Ditto
38 F. 7	7 days	146. 101·6°	—	Ditto	—	Ditto
40 M. 22	11 days	100. 100°	—	Ditto	—	Ditto
56 M. 26	6 days	96. 99°	—	Foul thick pus	—	Further drainage 13 days later
64 F. 7	5 days	120. 102°	None	Thick foul pus	Intestines somewhat red but "no peritonitis"	Two exploratory incisions then local abscess found Gangrenous. Appendix removed
66 F. 22	6 days	108. 99·2°	Clear fluid	Thin foul pus	—	Drainage

ACUTE APPENDICITIS WITH LOCAL ABSCESS.

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A	Of Exudate B	Of Exudate A	Of Exudate B	
—	—	—	B. pyocyaneus and gram-staining staphylococcus	C.
—	—	—	Bacillus coli	C.
—	—	—	Ditto	C.
—	—	—	B. pyocyaneus and staphylococcus staining by gram	C.
—	—	Sterile (culture from two situations)	Bacillus coli	C.
—	—	—	Ditto	C.
—	—	—	Ditto	C.
—	P.N. Non-gram bacilli : gram-cocci	—	Bacillus Coli and staphylococcus albus	C.
—	P.N. Non-gram bacilli. Group of gram-cocci	—	Bacillus coli and a gram-staining staphylococcus	C.
—	P.N. Non-gram bacilli. Groups of gram-staining cocci	—	Bacillus coli and staphylococcus albus. Two cultures from pus	C
—	Ditto	1. Right and left iliac fossae sterile	Bacillus coli and staphylococci	D. next day
—	Ditto	Staphylococcus albus	Bacillus coli and staphylococcus albus	C.

Table VIIIc.

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Observations at Operation	Operation
			A. In general Cavity	B. Contents of Abscess		
67 F. 13	6 days	— —	—	Thick foul pus	Intestines in general cavity rather red	Removal and drainage. Gangrenous and perforated
71 M. 23	4 days	116. 99°	—	Thin foul pus	Pus in centre of abscess much thicker and brownish	Drainage
75 M. 6½	5 days	144. 101·4°	—	Thick foul pus	—	Ditto
80 F. 19	13 days	124. 101·4°	Turbid odourless fluid	Thick foul pus	Intestines reddened and somewhat distended. Some omental adhesions. Local abscess in pelvis	Ditto
96 F. 51	6 weeks	Irregular septic fever	—	Brown foul pus	Faecal concretion escaped with the pus	Ditto
97 M. 18	13 days	Irregular fever with 8 rigors	No fluid	Greenish offensive pus	Liver red and soft. Local abscess. Concretion	1. Exploration 2. Drainage
100 M. 19	7 days	—	Sticky scanty exudate	Brownish offensive pus	Intestines reddened. No fluid	Drainage
10A M. 28	3 days	— 100·2°	—	Thin brownish pus	Oedema of skin. Fifth recurrent abscess	Ditto
30A M. 14	8 days	98. 102°	—	Thick, straw-coloured pus and gas	Perforated appendix	Removal and drainage

ACUTE APPENDICITIS WITH LOCAL ABSCESS (*continued*)

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A	Of Exudate B	Of Exudate A	Of Exudate B	
—	P.N. Non-gram bacilli, groups of gram-staining cocci and streptococci	Staphylococcus albus	Bacillus coli, a staphylococcus and a streptococcus	C.
—	P.N. Non-gram bacilli and groups of gram-staining cocci	—	Bacillus pyocyaneus and staphylococcus	C.
—	P.N. Non-gram bacilli	—	1. Sterile (aerobic). 2. Bacillus coli (anaerobic)	C.
—	P.N. No organisms	Sterile	Staphylococcus albus	C.
—	P.N. Groups of gram-staining cocci. Both gram-staining and non-gram bacilli	—	Aerobic and anaerobic : Bacillus coli and a staphylococcus	C.
—	P.N. Groups of gram-staining cocci. Gram-staining bacilli and non-gram bacilli	1. Sterile (Perit. cavity)	2. Staphylococcus albus (surface of liver). 3. Bacillus coli, aerobic and anaerobic of pus	D. next day. P.M. No abscess in liver
—	Ditto	1. Sterile	2. Bacillus coli, staphylococci, streptococci (pus)	C.
—	Ditto	—	1 and 2. Bacillus coli (pus) and a staphylococcus	C.
—	P.N. Non-gram bacilli. Groups of gram-staining cocci	—	Bacillus coli and staphylococcus albus (aerobic and anaerobic)	C.

TABLE VIIIc.

ase x and Age	Length of History	Pulse and Temperature	Character of Exudate		Observations at Operation	Operation
			A. In general cavity	B. Contents of Abscess		
A M. 14	7 days	— 102°	—	Offensive pus	Perforated appendix. Oedema of abdominal wall	Removal and drainage
6A M. 12	12 days	120. 102° rigor	—	Thick offensive pus	—	Drainage
43A F. 16	2½ days	— 103°	Clear fluid	Offensive pus	Intestines injected only near inflamed area. Gangrenous, friable appendix	Removal and drainage
47A M. 19	9 days	90 98·4°	—	Thin foul pus	Concretion escaped with the pus	Drainage
69A F. 41	7 days	120. 101°	—	Foul thick pus	—	Ditto
71A M. 15	8 days	96. 100·4°	—	Thin brown offensive pus and	Oedema of abdominal wall. Concretion escaped	Ditto
77A F. 27	10 days	92. 101·2°	Clear fluid	Offensive pus	Adhesions about appendix. Abscess on left side	1. Exploration 2. Drainage
78A F. 9	14 days	—	Clear non-smelling fluid	Thick offensive pus	—	Drainage
98A M. 5	10 days	120. 99·2°	—	Offensive pus	—	Ditto
1B M. 10	5 days	112. 100·6°	—	Thick offensive pus	Abdominal wall oedematous	Ditto

ACUTE APPENDICITIS WITH LOCAL ABSCESS (*continued*)

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A.	Of Exudate B.	Of Exudate A.	Of Exudate B.	
—	P.N. Non-gram bacilli, Groups of gram-staining cocci	—	Bacillus coli and a staphylococcus (aerobic and anaerobic)	C.
—	P.N. Gram-staining cocci and a long thin non-gram bacillus. No organism resembling bacillus coli	—	Staphylococcus albus	C.
—	P.N. Non-gram bacilli. Large stout gram-staining bacilli with rounded ends. Few gram-staining cocci	Staphylococcus albus	Aerobic: Bacillus coli and streptococcus Anaerobic: Bacillus coli and *B. aerogenes capsulatus*	C.
—	P.N. Cocci, diplococci, and short chains of cocci staining by gram Bacilli (not gram)	—	Aerobic: Bacillus coli and pneumococcus. Anaerobic: Bacillus coli	C.
—	P.N. Cocci, gram and not gram. Bacilli (not gram)	—	Aerobic and anaerobic: Bacillus coli	C.
—	P.N. Gram-staining cocci. Non-gram bacilli	—	Bacillus coli and staphylococcus albus	R. Empyema later
—	P.N. Groups of gram-staining cocci. Non-gram-bacilli	Sterile	Aerobic and anaerobic: Staphylococcus albus and bacillus coli	C.
—	P.N. Groups of cocci (gram). Bacilli (not gram)	Staphylococcus albus	Bacillus coli and staphylococcus albus	C.
—	P.N. Groups of cocci and very short chains (gram). Bacilli (not gram)	—	Aerobic and anaerobic: Bacillus coli	C.
—	P.N. Bacilli (not gram). Diplococci (not gram)	—	Aerobic and anaerobic: Bacillus coli	C.

Case Sex and Age	Length of History	Pulse and Temperature	Character of Exudate		Observations at Operation	Operation
			A. In general cavity	B. Contents of Abscess		
10B M. 26	3 days	100. 98°	—	Offensive pus	—	Drainage
12B M. 13	9 days	— 100°	—	Offensive pus	—	Ditto
21B M. 20	14 days	72. 99°	Clear fluid	Offensive pus, small quantity	Peritoneum reddened around abscess	Ditto
36B M. 13	5 days	112. 103°	Straw-coloured odourless fluid	Thick pus with comparatively little smell	Abscess post caecal	Ditto
37B M. 34	14 days	100. 103°	Ditto	Thick offensive pus	Post caecal abscess	Ditto
45B M. 15	7 days	— 101°	No fluid in general cavity	Offensive pus	—	Ditto
66B F. 23	7 weeks	140. 101°	—	Large gas containing abscess with offensive brownish pus	Very large abscess	Ditto
67B M. 36	14 days	88. 101°	Clear fluid	Thick offensive pus	—	Ditto
72B F. 28	5 days	— 102°	Clear odourless fluid	Yellowish offensive pus. Gas	—	Ditto

ACUTE APPENDICITIS WITH LOCAL ABSCESS (*continued*)

Microscopic Examination		Bacteriological Examination		Result
Of Exudate A.	Of Exudate B.	Of Exudate A.	Of Exudate B.	
—	P.N. and mononuclear cells. Enormous masses of bacilli (not gram). A few diplococci (not gram)	—	Aerobic and anaerobic : Bacillus coli	R.
—	P.N. mostly degenerated. Large numbers of non-gram bacilli both intra and extra cellular. Groups of cocci and diplococci (not gram). Long thin bacilli (not gram)	—	Aerobic and anaerobic : Bacillus coli . Cocci (not gram) present in cultures but not isolated	C
—	P.N. Two bacilli seen (not gram)	1. Staphylococcus albus	2. Staphylococcus albus. Bacillus coli (which died out)	R.
—	P.N. mostly degenerated. Bacilli (not gram). Cocci in groups (gram and not gram). Long thin bacilli (not gram)	1. Sterile	2. Aerobic and anaerobic : Bacillus coli	C. (very ill for 3 days
—	P.N. Bacilli (not gram). Groups of cocci (gram)	1. Staphylococcus albus	2. Aerobic and anaerobic : Bacillus coli	C. (no bad symptoms
—	P.N. mostly degenerated. Diplococci (gram). Bacilli (not gram)	1. Sterile	2. Aerobic and anaerobic : Staphylococcus albus. A streptococcus not staining by gram. Bacillus coli (which died out)	C.
—	P.N. many degenerated bacilli (not gram), cocci and diplococci (gram) ? shaped bacilli (gram)	—	Aerobic and anaerobic : Bacillus coli. Staphylococci (gram) not isolated	C.
1. No organisms	2. P.N. Bacilli (not gram). Long chains of cocci (not gram). Groups of cocci (gram)	1. Sterile	2. Attenuated streptococcus and bacillus coli, (which died out)	C.
1. No cells	2. P.N., mostly degenerated. Bacilli (not gram). Cocci in groups (gram)	1. Sterile	Aerobic and anaerobic : Bacillus coli	C.

TABLE VIIID.—SECONDARY LESIONS

Case	Sex and Age	Complication	Original Condition	Interval	Operation
92 Same case as 80	F. 19	Left subphrenic abscess	Local abscess	3 weeks	Drainage of abscess round spleen. Thick offensive pus and gas
62A	M. 70	Right empyema	Local abscess and right subphrenic abscess	None	Drainage. Foul pus
74	M. 22	Abscess of abdominal wall	Diffuse perforative peritonitis	10 days	Drainage. Brown foul pus
66A	M. 22	Residual intraperitoneal abscess	Local abscess, when appendix removed	2 years	Drainage. Offensive pus
85A	M. 15	Right subphrenic abscess	Local abscess	14 days	Drainage. Greenish pus, thick and offensive
41B	M. 12	Residual abscess	Diffuse peritonitis	2 years	Drainage. Thick offensive pus
49B	M. 20	Residual abscess on left side	Local abscess	1 month	Drainage. Thick pus with green colour
61B	M. 28	Residual abscess subhepatic	Local abscess	17 days	Drainage. Odourless pus
78B	M. 28	Acute pleuritis	Local abscess. Subhepatic abscess	3 weeks	Exploration above and below diaphragm

CONSEQUENT UPON APPENDICITIS

Microscopic Examination	Bacteriological Examination	Result
P.N. Groups of gram-staining cocci. Non-gram bacilli	Bacillus coli and Staphylococcus cereus albus	C.
P.N. Cocci and diplococci in short chains. Staining by gram. Non-gram bacilli	Bacillus coli	D. same day. P.M. Gangrenous appendix. Subphrenic abscess. No aperture in diaphragm
P.N. Groups of gram-staining cocci. Non-gram bacilli	Bacillus coli and staphylococcus albus	C.
P.N. Enormous numbers of cocci, diplococci and short chains which stain by gram. Non-gram bacilli	Aerobic and anaerobic: Bacillus coli and staphylococcus aureus	C.
P.N. Groups of cocci (gram). Bacilli (not gram)	Aerobic and anaerobic: Bacillus coli, staphylococcus albus, Bacillus proteus vulgaris	D. 2 days later. P.M. Multiple intraperitoneal abscess
P.N., mostly degenerated. Bacilli (not gram). Diplococci and short chains (gram)	Aerobic and anaerobic: Sterile	C.
P.N. Colon-like bacilli (not gram). Cocci (gram and not gram). Bacilli like ? (not gram)	Aerobic and anaerobic: Staphylococcus albus	C.
P.N. Two bacilli seen inside a leucocyte (not gram)	Aerobic and anaerobic: Sterile	R.
—	Pleura } Staphylococcus albus Peritoneum }	C.

TABLE VIIIE.

Case	Sex and Age	Character of previous attack	Interval	Observations at Operation	Condition of Appendix
88	M. 15	Abscess	4 months	Numerous adhesions. Clear non-smelling fluid around caecum. Small abscess at base of appendix containing non-smelling pus	Small healed perforation at middle
90	M. 30	Ditto	4 months	A few adhesions. No fluid	Old healed perforation
2A	M. 16	Ditto	5 months	Many firm adhesions. Intestines injected. No fluid	Much thickened. Concretion. Healed perforation. Kink Lumen patent
14A	F. 32	Catarrhal	6 weeks	Recent adhesions	Injected and catarrhal
19A	M. 6½	Abscess	8 weeks	Very few adhesions	Healed perforation
24A	F. 33	Acute	6 weeks	Tumour still present. Adhesions, but no pus	Thickened and adherent. Contained cheesy material
53A	F. 22	Abscess	4 months	Normal intestines. No fluid. Few adhesions round appendix	Healed perforation in distal half, which was obliterated
60A	M. 10	Ditto	3 months	Filmy adhesions, otherwise normal. No fluid	Short and thick. Concretion. Healed perforation
5B	M. 40	Acute	8 weeks	Many adhesions. No fluid	Appendix large, thick, and full of mucus. Lumen patent. Small abscess size of pin-head in wall
23B	M. 25	Ditto	9 days	Vascular adhesions	Small perforation sealed by adhesion to caecum

CHRONIC APPENDICITIS OR INTERVAL CASES.

Operation	Microscopical and Bacteriological Examination			Result
	Peritoneal Cavity	Surface of Appendix	Interior of Appendix	
Removal. Closure	Sterile	Sterile (Fluid round caecum) Staphylococcus albus (pus at base of appendix)		C. Primary Union
Ditto	Staphylococcus albus	—	—	Ditto
Removal. Drainage	*Films*: endothelial cells. No organisms. Staphylococcus albus	—	—	C.
Removal		Staphylococcus albus	—	Primary Union
Removal. Closure	Sterile	—	—	Ditto
Ditto	Sterile	A gram-staining staphylococcus	—	Ditto
Ditto	Sterile	—	—	Ditto
Ditto		Sterile *Film* from surface of appendix: Endothelial cells of and P.N. No organisms seen	Staphylococcus albus	Ditto
Ditto		Sterile	Aerobic and anaerobic from interior and from minute abscess: Bacillus coli *Films* from interior and from minute abscess: Enormous numbers of P.N. and mononuclear cells. Bacilli (not gram) many intracellular	Ditto
Ditto		Sterile	Aerobic and anaerobic from interior: Bacillus coli *Films*: Endothelial cells. No organisms	Ditto

TABLE VIIIE.

Case	Age and Sex	Character of previous attack	Quiescent Interval	Observations at Operation	Condition of Appendix
31B	F. 41	Abscess	3 months	Filmy adhesions—scanty	Large, greatly thickened, terminal inch obliterated. No sign of perforation
55B	M. 26	Ditto	2 months	Very adherent appendix	Contained dark mucoid fluid
57B	M. 28	Acute	1 month	Peritoneum normal	Adherent (recent) to caecum
60B	M. 14	Subacute	1 week	No fluid	Red with a little lymph on surface
79B	M. 5	Abscess	4 months	Ditto	Adherent scar of old perforation
76B	F. 19	Diffuse peritonitis. Later, subphrenic abscess	8 months	Minimal quantity of clear fluid	Very adherent scar of old perforation

CHRONIC APPENDICITIS OR INTERVAL CASES (*continued*)

Operation	Microscopical and Bacteriological Examination			Result
	Peritoneal Cavity	Surface of Appendix	Interior of Appendix	
Removal and closure		Staphylococcus albus	Anaerobic: Colon-like bacillus which died out *Films*: Endothelial cells of P.N. Enormous number of bacilli (not gram). Long thin bacilli (not gram)	C. suppuration
Removal. Closure. Drainage		Staphylococcus albus and Staphylococcus aureus *Films*: P.N. No organisms	Aerobic and anaerobic: Bacillus coli. Large mononuclear cells. A few P.N. Bacilli (not gram)	R.
Removal. Closure	Sterile	Sterile *Films.*: Large numbers of leucocytes, especially eosinophiles. No organisms	Anaerobic and aerobic: Staphylococcus cereus albus Few P.N. No organisms	C. Primary Union
Ditto	Sterile	*Films*: Large numbers of mononuclear cells and P.N. No organisms	Aerobic and anaerobic: Bacillus coli (interior) *Films*: Same as surface	Ditto
Ditto	Sterile	Staphylococcus albus	Bacillus coli *Films*: P.N. Bacilli (not gram). Cocci (not gram)	C. suppuration
Ditto	Staphylococcus albus	Staphylococcus albus	Bacillus coli and diplococci (gram) not isolated. Long chains of streptobacilli (gram) also not isolated. Anaerobic: Ditto *Films*: P.N. Bacilli (not gram). Long thin bacilli (not gram). Cocci (gram).	C. Offensive pus on 3rd day

TABLE IX.

Case	Age and Sex	Primary Operation	Interval	Character of Symptoms	Secondary Operation	Character of Exudate
40B	M. 31	Appendicectomy (Interval case)	22 hours	Pulse, 132. Temp. 101° Pain. Vomiting. Dulness in flank	Coeliotomy and lavage	Large amount of purulent fluid. Lymph all over abdomen (non-smelling)
90A	M. 12	Appendicectomy (previous abscess)	Few hours	Vomiting. Distension Hippocratic facies. Temp. 104°	None (material taken 4 hours after death)	Large amount of thick non-smelling pus. No gas
71B	F. 38	Hysterectomy	20 days	Well for a few days. Then mass in right broad ligament. Nineteenth day: Vomiting. Diarrhoea throughout	General cavity packed off and drainage of abscess	Adhesions. Clear odourless fluid in general cavity. Localised pelvic abscess with thick sweet pus. Caecum oedematous and friable
79A	F. 30	Removal of necrotic fibromyoma	14 days	Gradual onset of signs of diffuse peritonitis	Lavage. Drainage per vaginam	Fibrino-purulent
67A	F. 42	Colotomy	23 days	Gradual onset of peritoneal symptoms, with high fever	Drainage	Offensive pus in localised abscess on right side
41A	F. 37	Myomectomy	14 days	Symptoms of pelvic peritonitis with fever	Ditto	Thick, non-offensive pus in local abscess
24	M. 30	Removal of necrotic omentum in a strangulated hernia	25 days	Fever, vomiting and local tenderness	Incision and drainage	Thick, non smelling pus in local intra peritoneal abscess

Microscopical Examination	Bacteriological Examination	Result
Enormous numbers of P.N. Diplococci and streptococci (gram) almost entirely extracellular	1. Near caecum: Streptococcus pyogenes. 2. Near Sigmoid: Ditto 3. (Anaerobic): Sterile Blood culture at operation from basilic vein: Streptococcus pyogenes	D 44 hours after first operation
Large numbers of endothelial cells. No P.N. No organisms	1. (Exudate) 2. (Surface of intestine) } Streptococcus pyogenes	D. 40 hours after appendicectomy
1. Clear fluid: No organisms. 2. Pus: P.N., many degenerated. Staphylococci (gram). Bacilli (not gram). Bacilli (gram)	1. Clear fluid (Sterile). 2. Pus (aerobic and anaerobic): Pure culture of Bacillus pyocyaneus Blood culture, 26th day: Streptococcus pyogenes and staphylococcus albus	D. 27 days after hysterectomy
Diplococci in chains (not gram). Enormous numbers of P.N.	Staphylococcus albus (aerobic and anaerobic)	D. third day
Enormous numbers of P.N. bacilli (not gram) and cocci (gram)	Bacillus coli	D. ninth day. P.M. Diffuse peritonitis
Cocci (gram)	Staphylococcus aureus	R. with faecal fistula
—	Staphylococcus albus, staphylococcus aureus and staphylococcus citreus	C.

TABLE X.

Case	Sex and Age	History	Character of Symptoms	Complications	Operation	Character of Exudate, etc.
A. STREPTOCOCCIC						
39A	F. $\frac{7}{12}$	10 days	Diffuse cutaneous erysipelas	Peritonitis	None. Cultures taken 20 minutes after death	Turbid odourless fluid
60	M. 50	24 hours	Abdominal pain and vomiting. Pulse 72	Sarcoma of omentum	Exploratory coeliotomy	Clear, odourless fluid. Intestines red and distended. Flakes of lymph
B. PNEUMOCOCCIC						
89A	F. 6	48 hours	Diarrhoea. Vomiting. Temp. 105·2°. Pulse 140. Abdominal tenderness. Cerebral irritation	Vulvitis Pyometra	Lavage. Closure	Thick yellow pus. Intestines red. Appendix normal. Peritonitis more marked in lower half
86B	M. 7 weeks	2 days	Redness and oedema of abdominal wall. Pulse 120. Jaundice. Temp. 100°. Vomiting	—	None. Cultures 20 minutes after death	Green turbid fluid and flakes of lymph. Peritoneum much injected. Appendix normal
85B	M. 2½	?	Temp. 100°. Pulse 136. No vomiting. Diarrhoea	Rickets. Bronchopneumonia Empyema (right). Suppurative pericarditis Mediastinal lymphadenitis	None. Cultures 15 minutes after death	Thick greenish-yellow pus, very little. Abnormal appearance of peritoneum

See also Appendix Table

Microscopical Examination	Bacteriological Examination	Result
PERITONITIS		
P.N. in large numbers. Diplococci and streptococci	Exudate : Streptococcus pyogenes and bacillus coli Intestinal surface : Ditto	D. P.M. Universal peritonitis
No organisms	Exudate at a distance : Sterile. Exudate close to growth : Staphylococcus albus and staphylococcus aureus Surface of growth : Streptococcus pyogenes	D.
PERITONITIS		
1. From vagina : Diplococci (intracellular chiefly) (not gram). 2. Peritoneal exudate : P.N. Diplococci (extracellular) (gram) 3. Interior of uterus : Diplococci (short chains) extracellular (gram)	1, 2. Peritoneal exudate : Pneumococcus 3. Uterus : Pneumococcus	D. 2 hours after operation. A drachm of pus in uterus. No other lesion
P.N. Diplococci and short chains of diplococci (gram)	Pneumococcus	D. third day. P.M. No other lesion
P.N. in large numbers. No organisms	Pneumococcus from pericardium, pleura, lungs. Peritoneal exudate : Sterile	D. suddenly

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